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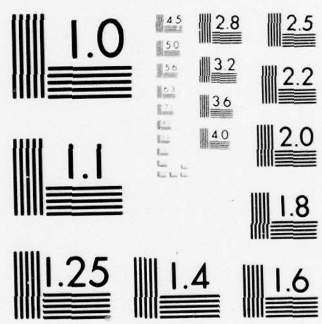

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A STUDY OF THE ACQUISITION AND MANAGEMENT OF SMALL-SCALE AUTOMATIC DATA PROCESSING EQUIPMENT

THESIS

AFIT/GSM/SM/78S-19

Donnie B. Self
Capt USAF

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AFIT/GSM/SM/78S-19

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A STUDY OF THE ACQUISITION AND MANAGEMENT OF SMALL-SCALE AUTOMATIC DATA PROCESSING EQUIPMENT

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~~Capt USAF~~

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Preface

I feel that the Air Force faces a great challenge in exploting the full potential of computer technology. This research was performed to identify and investigate current problems in acquiring and managing small computers. It is hoped that the results of my research may, in some small way, be of use in solving these problems.

Appreciation and thanks must be extended to numerous people who aided me with their time and efforts. First, Dr. Charles W. McNichols, my thesis advisor, contributed significantly to this study in many ways. His expertise in research methods and his insight and encouragement were particularly valuable to me. I also thank my reader, Dr. Young, for his assistance. I am particularly indebted to the twenty-three individuals who participated in the research interviews. This study would not have been possible without their assistance.

I express my greatest thanks to Linda, my wife, for her understanding and encouragement throughout the thesis effort.

Capt Donnie B. Self

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Abstract

In 1965, Congress passed Public Law 89-306 establishing a government-wide automatic data processing (ADP) management program. However, in the thirteen years since passage of the law, technological advances have significantly changed the capabilities, costs, and applications of automatic data processing equipment (ADPE). This research effort is a study to determine whether current ADP acquisition and management policies are appropriate for small-scale ADPE. A literature review was used to identify the technological changes that have occurred in ADPE since 1965, to determine if the ADP management program was founded on particular technological assumptions, and to identify the present Air Force requirements for the acquisition and management of ADPE. Also, twenty-three interviews were held with ADP managers and ADPE users. These interviews were used to identify and examine current problems in acquiring and managing small-scale ADPE. The writer concluded that while the basic ADP acquisition and management policies remain valid for small-scale ADPE, significant problems exist in the implementation of these policies. It was determined that these problems relate to the increasing number of low cost ADPE

acquisitions. It was concluded that ADPE acquisition approval authority needs to be further decentralized and that acquisition procedures need to be simplified.

A STUDY OF THE ACQUISITION AND MANAGEMENT OF SMALL-SCALE AUTOMATIC DATA PROCESSING EQUIPMENT

I. Introduction

> The effective and efficient exploitation of computer techniques and continued advancements in the state of computer technology have become decisive factors in the economic and military posture of the Nation. If we falter in the development and application of computers, so as to lose our present overwhelming advantage, then the power and the prestige and the prosperity of this Nation as contrasted to other world powers will be compromised. The Federal Government . . . . as the world's largest user of computers must . . . fulfill our mandate to the taxpayers to manage this costly equipment efficiently and effectively. We must lead the way in the development of effective national policies that will assure our continued superiority in the area of computers (House Government Activities Subcommittee, 1971:1-2).

The above statement characterizes the importance of computers to our society and illustrates the paramount need for effective computer management policies within the federal government. In 1965, Congress passed Public Law 89-306 establishing the present government-wide automatic data processing (ADP) management program. The purpose of this program was to provide for the economic and efficient acquisition, utilization, and management of

automatic data processing equipment (ADPE). However, in the 13 years since passage of the law, technological advances have significantly changed the capabilities, costs, and applications of ADPE. The purpose of this study is to examine the acquisition and management of the advanced technology "small-scale" ADPE (see Appendix A for the definition of "small-scale" ADPE).

Background

Public Law 89-306 was passed by Congress in 1965 to correct the pervasive mismanagement of ADPE in the federal government. As governmental computer usage increased during the 1950's, management policies applicable to calculators and office equipment were applied to ADPE. Government agencies acquired computers independently without regard to government-wide needs, available capabilities, or volume procurement discounts. Between 1958 and 1965, the Comptroller General submitted more than 100 audit reports to Congress showing a pattern of ADPE mismanagement. As a result, Congress passed Public Law 89-306 "to provide for the economic and efficient purchase, lease, maintenance, operation, and utilization of automatic data processing equipment by Federal departments." (Reproduction of Senate Report No. 938, 1966:3859) The law set up an ADP management structure in the Executive Branch and assigned responsibilities for providing government-wide ADP policy and

control. Within the Department of Defense (DOD) and the Air Force (AF), this policy has been implemented for general-purpose ADPE by DOD Directive 4105.55 and the AF 300-series regulations. This system of directives and regulations established a separate, specific, and unique process for the acquisition, control, planning, budgeting, and financing of ADPE.

What is the status in government ADP 13 years after Public Law 89-306 established a special, centralized ADP management program? In 1976, the House Government Operations Committee reviewed the administration of the law since its passage. The committee found that ". . . the Act has been poorly administered and inefficiently implemented." (The Federal ADP Procurement Maze, 1977:50) Since 1965, the General Accounting Office has issued over 175 reports dealing with ADP problems, an average of one every month. (The Federal ADP Procurement Maze 1977:50) The present system of ADP management has been criticized by Congress, by the government agencies that must use the system, by the agencies operating the system, and by the computer industry. (Baynard, 1976; Borklund, 1973; The Federal ADP Procurement Maze, 1977)

One common reason given for ADP management problems is that the law and the basic ground rules of the system were ". . . written in 1965 around 1965 technology." (The Federal ADP Procurement Maze, 1977:49) Senate Report 938 indicates that the law was

based on the expectation of an extensive use of large general-purpose computers and time-sharing in third generation ADPE. (Reproduction of Senate Report No. 938, 1966:3868-3870) While this type of time-sharing computer system did develop, another branch of ADPE also developed--the mini/microcomputer. This technology has brought about tremendous change in the capabilities, costs, size, and applications of ADPE. In turn, these changes have impacted the management of ADPE.

Previous Research

Two recent studies, one by the House of Representatives' Committee on Government Operations (1976) and the other by the General Accounting Office (1977), indicate problems in managing small-scale ADPE under the present ADP policies and procedures. House Report No. 94-1746 concludes that ". . . immediate cost benefits and time savings can be realized through the institution of simplified procedures for procurement of smaller dollar value items." (House Report No. 94-1746, 1976:12) Specifically included in this category of small dollar value items were minicomputers, peripherals, software, and maintenance. The Committee recommended that ". . . new procedures should be established whereby user agencies could procure ADP items below $250,000 without the need to obtain a delegation of authority from GSA (General Services Administration)."

(House Report No. 94-1746, 1976:12) To date this recommendation has not been implemented.

In a like manner, the General Accounting Office (GAO) found that for minicomputer acquisitions " . . . intolerable procurement delays were resulting from their (user agency's) own internal documentation requirements. Most of these requirements were developed before minicomputers appears on the scene." (Report to the Congress by the Comptroller General of the United States, 1977:19-20) The report went on to recommend simplified procurement requirements for minicomputers. It is of interest that neither the GAO report nor the House report considered the management implications of the latest ADPE technology--the microcomputer.

In June 1977, the Office of Management and Budget announced the formation of a Federal Data Processing Reorganization Project. The project team, composed of individuals from government and private industry, is studying some 31 ADP issues. According to Mr. Wayne G. Granquist, project associate director, the project will focus on three main areas: 1) improving government services through the application of computer technology, 2) improving the acquisition, management and use of ADP resources, and 3) clarifying agency jurisdictions in computer issues. (Leavitt, 1977:1) The project should be completed by late Fall of 1978.

Statement of the Problem

The above mentioned studies and this writer's own experiences in ADPE management indicate that problems exist in the acquisition and management control of small-scale ADPE. Based on initial research this writer hypothesized that these problems occur because the current ADPE acquisition and management policies are not appropriate for small-scale ADPE. Alternatively, the problems may result from some other factor such as inadequate training of ADP management personnel. However, problems do exist in acquiring and managing small-scale ADPE and it is the purpose of this thesis to investigate these problems and their cause. Specifically, the thesis addresses the question: Have technological advances in ADPE rendered the current ADPE acquisition and management control policies and procedures inappropriate for small-scale ADPE?

Objectives

The overall objective of this study is to determine whether technological advances in ADPE have rendered the current ADPE acquisition and management policies inappropriate for small-scale ADPE. To provide a systematic approach to accomplishing this overall objective, the following six sub-objectives will be used.

1. Identify the major changes that have occurred in ADPE technology, costs, capabilities, and applications since 1965

and the projected changes in the next 5-10 years.

2. Determine if the present ADP management program was based on particular technological assumptions.

3. Identify the major requirements under the present ADP management program for the acquisition and management of ADPE.

4. Identify and analyze current problems and issues in the acquisition and management of small-scale ADPE.

5. Determine the major effects small-scale ADPE is having on the ADP management program.

6. Determine the effect the ADPE management program is having on AF utilization of small-scale ADPE.

Limitations

The study is subject to the following limitations:

1. The main focus of the study is on the impact of technological advances in ADPE on Air Force ADP management. The impact of other factors, such as politics, manning, and funding are not considered in detail.

2. ADPE which is internal to a combat weapon system is excluded from the study.

3. The acquisition and control aspects of the study are limited to the general requirements of the AF 300-series

regulations. The study does not address aspects such as specifications, comparative evaluation of hardware, benchmarking, acceptance testing, budgeting, and financing of ADPE.

4. While some guidelines may be suggested, the study does not attempt to design a new ADP management system to eliminate all problems which are identified.

Assumptions

Much of the data required for this research effort was gathered by personal interviews (see Methodology). Therefore, an underlying assumption is that the personnel interviewed truthfully expressed their problems and opinions. This writer perceived this to be true. Also, the correlation of the data from independent interviews and congruency of the data with previous studies support the validity of this assumption.

Methodology

The methodology used in this research effort consisted of three principal activities: a literature search, personal and telephone interviews, and analyzing the data collected. A literature review was used to accomplish the first three sub-objectives of this study. A more extensive methodology utilizing both a literature review and

interviews was used to achieve the last three sub-objectives. The methodology for sub-objectives four through six is only overviewed here; a detailed discussion is provided in Chapter Five, immediately preceeding these sub-objectives.

To accomplish the first three sub-objectives of this study, it was necessary to collect data concerning 1) technological advances in ADPE, 2) the historical development of the ADP management program, and 3) current policies and procedures for acquiring and managing ADPE. A literature review was used to gather this data. Information on ADPE technology was found in numerous books and periodicals. Material on the history of the ADP management program was obtained from periodicals of the day and Congressional documents. A review of pertinent Air Force regulations provided data on current ADPE policies and procedures. Overall, the literature review provided abundant material and proved very enlightening.

To accomplish the last three sub-objectives of this research, it was necessary to collect data concerning 1) current problems in the acquisition and management of small-scale ADPE, 2) the effects of small-scale ADPE on the ADP management program, and 3) the effect of the ADP management program on Air Force utilization of small-scale ADPE. The primary means of gathering this data was through interviews with ADP management personnel and ADPE users. The rationale for this methodology, the preparation of interview

questions, a description of the individuals interviewed, and the ensuing data analysis are discussed in Chapter Five.

Since the personnel interviewed were asked to admit problems and discuss somewhat controversial topics, this thesis is written on a non-attribution basis. The only identification attached to interview datum is that it represents the opinion of a base, MAJCOM, or HQ USAF ADP administrator or and ADPE user. To further insure non-attribution, notes taken during the interviews were destroyed at the end of this study.

Thesis Organization an Overview

This thesis is organized into eight chapters. This introductory section constitutes Chapter One of the thesis. Chapter Two is an overview of technological progress in computers. The early electro-mechanical relay computers and the first generation computers are briefly described. The chapter emphasizes technological changes that have occurred since the early 1960's when P.L. 89-306 was first proposed in Congress. Chapter Three discusses P.L. 89-306 and the ADP management program it established. The legislative history of the law is examined to determine whether the ADP management program was founded on any particular technological assumptions. Chapter Four outlines the current policies and procedures for acquiring and managing ADPE. In Chapter Five, the methodology used to

accomplish the remaining research sub-objectives is discussed. Current problems in acquiring and managing small-scale ADPE are identified and examined in Chapter Six. In Chapter Seven, the last two research sub-objectives are addressed. These involve the effect small-scale ADPE is having on the ADP management program and, conversely, the effect the ADP management program is having on Air Force utilization of small-scale ADPE. In Chapter Eight, results from each of the six sub-objectives are summarized and a determination is made as to whether technological advances in ADPE have rendered the current ADP acquisition and management policies inappropriate for small-scale ADPE.

II. An Overview of Computer Progress

This chapter addresses the first sub-objective of the thesis research: identification of the major changes that have occurred in ADPE costs, capabilities, and applications since 1965, and the projected changes in the next five to ten years. The purpose of this sub-objective is to document and illustrate the extraordinary growth and rapid changes that have characterized the computer field. The emphasis of this chapter begins with the second generation of computer technology. It was during this period that P.L. 89-306 was enacted by Congress. By identifying the technological state-of-the-art when the ADP management program was established and then examining the radical changes that have subsequently occurred, one may glean an insight into the present ADPE acquisition and management problems.

This chapter is organized into six main sections. The first two sections provide some brief background material on the early electronic relay computers and the first generation computers. The emphasis of the chapter begins with the section on second generation computers. Within this section, the technology and performance of second generation computers are described; then the developments and trends in the second generation are discussed. Similar

information is provided in the following two sections which discuss, respectively the third computer generation and computer developments from 1971 to 1978. The final section discusses the future of computer technology with emphasis on the next five to ten years.

Electromechanical "Relay" Computers

By the late 1930's, the requisite technology existed to develop an automatic computer. World War II provided the need and the financial resources for this development. These early automatic computers were constructed primarily of electromechanical telephone relays. Although electronic computers came into use beginning in 1945, they were prone to uncertainties and thus relay machines were being developed and delivered through the early 1950's. Two scientific groups in the United States simultaneously developed these relay computers.

The Harvard Mark I. In 1937, Howard Aiken, a Harvard graduate student, proposed the creation of a large scientific calculator. IBM President, Thomas J. Watson, was impressed with Aiken's plan and assigned four IBM engineers to the project. The computer was constructed at IBM's development laboratory as a government supported project during World War II. It was delivered to Harvard in February 1944. By May, the Mark I (officially named the Automatic Sequence Controlled Calculator) was solving ballistics problems

for the Navy. It remained in use at Harvard until 1959.

The technology of this notable machine is worth examination. The Mark I was 51 feet long, 8 feet high, and over 6 feet wide. It was constructed almost entirely of mechanical switches and when operating, the opening and closing of thousands of switches sounded "like a roomful of ladies knitting." (The Age of Miracle Chips, 1978: 56) Data and instructions were input to the machine using punched paper tape. The Mark I could perform three additions per second and multiply two 23-digit numbers in about five seconds. (Randell, 1973:187, 188; Thomas, 1965:60, 61; Eames, 1973:122, 123, 135; Stifler, 1950:185; The Age of Miracle Chips, 1978:56)

Bell Telephone Laboratories. Beginning in 1940, the Bell Laboratories, under the leadership of George Stibitz, developed a series of relay calculators which culminated in the Model V relay computer in 1946. In 1937, Stibitz began investigating the possibility of using telephone relays to construct a calculator. The Model I calculator became operational in 1940. During World War II, Bell Laboratories developed Models II-IV for the military primarily to solve fire control problems. These calculators are notable because they had an extensive self-error-checking capability. The Model V, a general purpose, program-controlled computer was delivered to the National Advisory Committee on Aeronautics at Langley Field, Virginia, in 1946. It consisted of two processing units and was the

forerunner of multiprocessing systems. The Model V was constructed from ordinary telephone system parts and consequently was highly reliable. It set the standard among early computers in reliability, versatility, and ease of switching from one task to another. (Eames, 1973:121, 140, 141; Randell, 1973:238, 239)

The First Generation

In 1945, the ENIAC ushered in the age of the general-purpose electronic computer. The first generation computers were characterized by vacuum tube logic technology. This period saw many important "firsts" in computer history.

ENIAC (Electronic Numerical Integrator And Computor). In 1945, ENIAC became the first general-purpose electronic computer to operate successfully. John Mauchly and J. P. Eckert, Jr., are given primary credit for its development at the Moore School of Electrical Engineering at the University of Pennsylvania. The ENIAC was developed, with significant government support, principally to compute ballistic tables.

The design of ENIAC began in 1942 with a paper by Mauchly entitled "The Use of High Speed Vacuum Tube Devices for Calculating." This use of electron tubes instead of mechanical relays tremendously improved the speed of computers. As a comparison, the Mark I required one-third of a second to add two numbers;

ENIAC could add numbers at the rate of 5000 per second. (Randell, 1973:289-291; Thomas, 1965:62; Eames, 1973:132)

> The ENIAC's importance in the development of computers is unquestioned. It was the first large electronic computer to become operational, and many scientists and mathematicians visited the Moore School to learn about the machine, and in some cases to use it. (Randell, 1973:291)

<u>EDVAC</u>. The EDVAC was the second electronic computer constructed at the Moore School. It is noted primarily because the concept of a stored program originated during its design. With the earlier ENIAC, instructions had to be wired into the machine by changing its cable and circuit configuration. This could require days of work. John von Neumann solved this problem with the invention of the stored program. In 1945, he wrote one of the most significant papers in computer history. In it von Neumann

> . . . suggested that the instructions for the computer--always before entered on punched paper tape, or by plugboards--could be stored in the computer's electronic memory as numbers and treated in exactly the same manner as numerical data. (Eames, 1973:137)

Additionally, von Neumann presented a suggested architecture for computers. His basic design is used in almost all modern computers. The EDVAC became operational in 1951 and it continued in use through 1962. (Randell, 1973:350-352; Eames, 1973:137, 154)

<u>IAS (Institute For Advanced Studies)</u>. Following World War II,

John von Neumann returned to his post at the Institute for Advanced Studies at Princeton and began work on a computer for the Army. "Although the IAS computer was not finished until 1952, the series of reports that were issued by the project, starting in 1946, were widely circulated and served many people as textbooks on logic design and programming." The computers of today are still organized on the concepts developed by von Neumann. (Randell, 1973:352)

UNIVAC. The UNIVAC was the first computer designed for commercial applications. Design of the UNIVAC began in 1947 and the first machine was delivered to the Census Bureau in 1951. In 1954, a UNIVAC I was installed at a General Electric appliance plant in Louisville, Kentucky. This was the first large computer sold to private enterprise for non-scientific applications. (Thomas, 1965:73, Eames, 1973:158, 162; Schussel 1965:54, 55; Randell, 1973:352)

IBM. Following the cooperative work on the Harvard Mark I, IBM developed a series of computers that made it the dominant company in the computer industry by the late 1950's. The first independently developed IBM machine was the Pluggable Sequence Relay Calculator introduced in 1944. In 1948, the IBM Selective Sequence Electronic Calculator became operational. This machine was a hybird constructed of vacuum tubes and relays. It provided IBM with valuable experience and some important patents.

In 1952, IBM delivered its first 701 computer which was the forerunner of a series of scientific computers extending into the early 1960's. The IBM 701 was a vacuum tube machine similar in

design to von Neumann's IAS computer. In 1954, IBM delivered the 702 which was the company's first large business computer. IBM delivered its first model 704 in 1956. This was a highly sophisticated scientific computer incorporating features such as magnetic core memory, floating point arithmetic, and indexing. The IBM 704 was widely accepted and led IBM to its dominance of the computer industry. (Bell, 1971:515; Schussel, 1965:55; Randell, 1973:187, 188, 352; Schussel, 1965b:59, 61)

The Second Generation

The second generation of computers was characterized by transistor (or solid-state) logic technology. This period in computer history is generally dated from 1958 to 1966. While progress in the first generation was primarily in the architecture and organization of computers (culminating in the von Neumann concepts), second generation progress was characterized mainly by vast improvements in electronic circuitry. Thus, the second generation was not so much revolutionary as evolutionary with steadily increasing computer performance and reliability and decreasing cost and size.

Given this change in the nature of computer progress, the presentation of this paper will shift from a chronology of events and move toward a more generalized discussion. Since the second generation was based on transistor technology, the origin and evolution of this form of circuitry is discussed first. Then, the general progress in computer performance from 1958 to 1966 is briefly

reviewed. Finally, the major developments and trends during this time are examined.

One should keep in mind that Public Law (P.L.) 89-306 originated during the latter part of the second computer generation. A bill embodying the concepts of P.L. 89-306 was first introduced in the House of Representatives in 1963 by Congressman Jack Brooks. A modified version of this bill was enacted by Congress as P.L. 89-306 in 1965. Therefore, it is important to note the state-of-the-art and the prevalent trends in computing during this period of time.

Transistor Technology. The invention of the transistor at Bell Laboratories in 1947 was a milestone in physics and eventually in computer development. In the late 1930's, William B. Shockley, a physicist at Bell Laboratories, began investigating the development of a solid-state device to replace electromechanical switches in telephone exchanges. After World War II, Shockley along with John Bardeen and Walter Bratain returned to this problem and began studying field-effect amplification in germanium, a semiconductor.

"A transistor is a device that utilizes a semiconductor to control or to amplify, or both, small electrical currents." (Semiconductors and Insulators, Theory of, 1974:523) Functionally, it can be used as a switching device replacing relays or vacuum tubes in a computer. The advantages of the transistor for computer construction are its low fabrication costs, small size, low heat generation, low energy requirements, and high reliability. Transistor technology developed rapidly during the 1950's and early 1960's. To illustrate the improvement, cost per transistor decreased from about $10 to

$0.10, failure rate per billion hours decreased from 50,000 to 1, and frequency response (a performance measure) increased from 10 to 10,000 Mc. (Kaenel, 1970:8; Hittinger, 1973:48,49; Semiconductors and Insulators, Theory of, 1974:523; Packard, 1978:18)

Computer Performance. Based on this transistor-technology circuitry and improvements in magnetic core memories, computer performance increased during the second generation while relative cost decreased. One indication of this improvement in performance was the decreased time required to add two numbers as illustrated in Table 1.

TABLE 1: Computer Addition Times

(Adams, 1962)

Machine	Technology	Introduced	Add Time in Microseconds
Univac I	vacuum tube	1951	282
Burroughs 220	vacuum tube	1958	200
Philco 2000	transistor	1958	15
IBM 7090	transistor	1959	4.4
IBM STRETCH	transistor	1961	1.5
CDC 6600	transistor	1964	1.3

From first generation computers to the second generation machines of the mid-1960's, logic circuit speed improved by a ratio of about

200 to 1. Also, from 1950 to 1965 internal memory performance increased by a factor of up to 2000. (Improvements in Hardware Performance, 1964:14)

An analysis of computer performance changes from 1950 through 1967 has been published by Dr. Kenneth E. Knight (Knight, 1966; Knight, 1968) Dr. Knight evaluated 318 computer systems and derived performance/cost parameters for scientific and commercial applications of each system. One parameter that particularly illustrates the improvements in performance relative to cost is the ratio of the number of operations per dollar cost. Table 2 shows the annual change in this ratio during the second generation.

TABLE 2: Computer Performance Improvement

(Knight, 1966; Knight, 1968)

Year	Annual Percent Improvement	
	Scientific Computation	Commercial Computation
1959	57	12
1960	84	70
1961	116	82
1962	110	104
1963	130	170
1964	55	140
1965	225	200
1966	65	130

Integrated circuit technology, characteristic of third generation computers, was first introduced in 1964 and 1965 and probably influenced the performance improvement shown in 1965. Also, it should be pointed out that factors other than computer hardware improvements contributed to the performance improvements. However, transistor circuit technology and magnetic core memory were undoubtedly significant factors. Overall, the second generation was a period of increasing performance capabilities in computers.

Developments and Trends. The second generation was a period of growth and maturation for the computer field. The writer will now review some of the major developments and trends of this period. As mentioned earlier, one should keep in mind that P.L. 89-306 was written and enacted during this period.

The second generation was a period of expansion in the computer field. The first commercially available transistor computer, the Philco 2000-210, was introduced in November, 1958. In the following seven years, the computer industry grew rapidly. In 1960 alone, 35 new general purpose computers were marketed. By July 1965, *Datamation* magazine counted 134 general purpose computers being offered by United States manufacturers (this number included some early third generation machines). The number of computers in operation also increased--from about 2500 in 1959 to 15,000 in 1966. Within the federal government, the number of computers

increased from 800 in 1961 to 1400 in 1963 to 2000 in 1965.

> The most popular second-generation machines by far were IBM's small-to-medium-scale business-oriented IBM 1401 and their scientific-oriented IBM 1620 computer. IBM's 7090-7094 dominated the large-scale computer market. (Adams and Harden, 1973:230)

Other notable machines introduced during this time period were the Univac LARC (1960), IBM 7030 Stretch (1961), Burroughs 5000 (1962), and the CDC 6600 (1964). In 1965, IBM began deliveries of their early System/360 models. These machines were constructed in a hybrid technology composed partly of third generation integrated circuit techniques and partly of second generation transistor techniques. Thus, the System/360 marked the transition from the second to third generation. During this transitional period the first embodiments of the present-day minicomputer and electronic calculator began to appear. However, discussion of these developments is more appropriate under the third generation of computers following an explanation of integrated circuitry.

Although computing was a relatively unstructured discipline during the late 1950's, several distinct trends had emerged by the mid-1960's. Perhaps the most important of these trends was the use of timesharing. "Timesharing is the simultaneous utilization of a computer system from multiple terminals." (Spencer, 1974:345) The concept is based on the economy-of-scale argument that it is

cheaper to have many users share one large computer than for each to have his or her own computer. Several universities began developing timesharing system in 1962-1963 and by 1965 numerous timesharing computers were commercially available. During this period, timesharing was probably the dominant trend and philosophy in computing--one enthusiast went so far as to predict the disappearance of all other forms of operation. (Opler, 1967:32) In addition to timesharing, several other trends became evident.

In an October 1964 Datamation article, David Weisberg identified three computing trends.

> The first is the evolution of an integrated product line with virtually every peripheral device built by a manufacturer capable of being attached to any central processor in its product line. This, together with programming similarity between processors, results in a significant level of compatibility. (Weisberg, 1964:45)

Second was a constant increase in computer speeds achieved by faster memories, overlapping memory accesses, use of scratch pad memories, more powerful instructions, and parallel execution of instructions. Third, manufacturers were extending the life span of existing systems by bringing out faster versions of present computers. Again, it should be noted that these were the prevailing trends when P.L. 89-306 was enacted. (Adams, 1962:33; Amdahl, 1967:25; Weisberg, 1965; Gruenberger, 1970:69; Adams, J., 1973: 230, 232, 243; Phillips, 1962:23; Mahoney, 1964:26; Senate Report

No. 938, 1966:3680; Bell, 1971:564; Spencer, 1974:345; Weisberg, 1966:55; Kurtz, 1977:2-72; Opler, 1967:32; Weisberg, 1964:45)

Third Generation, 1966 to 1971

The third generation of computers is characterized by integrated circuit logic technology. The third generation is generally considered to have begun about 1966. By this date integrated circuitry had advanced to the point that it was being utilized in most new computers being marketed. From the mid-1960's to the early 1970's, technical innovations and advances significantly affected the performance, cost, and size of computers. The end of the third generation is not clearly demarcated. This writer selected 1971 as the ending date because the microprocessor was commercially introduced that year.

Integrated circuitry and the third generation of computers are now discussed. First, the development of integrated circuit technology up to 1971 is reviewed. Then the progress in computer performance, resulting primarily from integrated circuits, is briefly examined. Finally, several trends and developments that occurred during the third generation are discussed. The emphasis in this discussion is on the development and evolution of small computers.

Integrated Circuits.

> An integrated circuit is a combination of interconnected circuit elements, such as transistors, resistors, and diodes, that are inseparably

> associated with a continuous base material (substrate) by various processing operations that simultaneously form a large number of such elements. (Moore, 1974:658)

The integrated circuit concept was a natural outgrowth of the progress in transistor technology. In the late 1950's, Fairchild Semiconductor developed a planar process for fabricating transistors. Hundreds of transistors were formed in a single semiconductor wafer and then separated for subsequent reconnection on circuit boards. From this process came the integrated circuit in which the separation and connection of the circuit elements is accomplished electrically within the semiconductor chip instead of physically on a circuit board. Integrated circuits became commercially available in the early 1960's. These rudimentary devices contained about a dozen circuit elements on a semiconductor chip measuring a few millimeters on a side and cost about $10. By 1964 improvements in manufacturing techniques had reduced costs so that integrated circuit logic gates were available for $2.55 and flip-flops cost $6.50. An article in Datamation stated that these cost reductions " . . . heralded the entry of integrated-circuit manufacturers into the commercial computer market." (Richmond, 1965:31)

From the mid-1960's to 1971 was a period of continual progress in integrated circuit technology. During this time the number of components that could be contained in a single semiconductor chip

approximately doubled every year. The number of components per chip is often referred to in terms of level of integration. Small-scale integrated (SSI) circuits contain between 50 and 100 components and represented the state-of-the-art until about 1965. Medium-scale integrated (MSI) circuits containing between 100 and 1000 components were the prevalent technology from 1965 to 1969. Large-scale integrated (LSI) circuits were introduced about 1970. By 1971, LSI circuits containing about 5000 components were being produced. Concurrent with this increase in components per chip was a decrease in cost. Between 1965 and 1971, integrated circuit logic costs decreased by a factor of 27. Similarly, the speed of integrated circuit logic improved during this timeframe. The integrated circuit logic gates of 1966 had propagation delays of about 40 nanoseconds. By 1971, circuits were available which had only a 5 nanosecond delay. Also by 1970, semiconductor technology memory elements began supplementing or replacing magnetic core memory in computers. These semiconductor memories operated at about twice the speed of core memory.

The advances in integrated circuit technology made possible the third generation of computers.

> The benefits of integrated circuits include smaller size, lower power consumption, often increased speed of operation, improved reliability, and vastly reduced cost. In addition, system

> design and realization are simplified when using integrated circuits, since most of the required interconnections have already been made within the integrated circuits themselves. (Moore, 1974:658) (Richmond, 1965:30, 31; Noyce, 1977: 65, 67; Hittinger, 1973:50; House, 1971:98; House, 1971b:26, 28)

Computer Performance. The advances in computer component technology resulted in corresponding improvements in computer performance. Between 1960 and 1970, computer speeds increased by a factor of 1000 while the costs of computation simultaneously decreased by a factor of 500. Table 3 illustrates the improvement in computer central processing unit (CPU) cycle time between the second and third generations and within the third generation itself.

TABLE 3: Computer Performance

(Kaenel, 1970:11; Stone, 1975:177; Bloch, 1978:70)

Machine	Year	Generation	CPU cycle time (microseconds)
IBM 7090	1960	2	2.2
IBM Stretch	1961	2	.6
CDC 6600	1964	2	.1
IBM 360/75	1965	transition	.195
IBM 360/91	1967	3	.075
IBM 360/85	1969	3	.080
CDC 7600	1969	3	.0275
IBM 360/195	1971	3	.054

Trends. Several trends were evident during the third computer generation. The writer will discuss three of these trends--timesharing, minicomputers, and compatibility. Timesharing and compatibility were continuations of second generation trends which had influenced P.L. 89-306. The development and advances in minicomputers was a trend that ran counter to the factors that influenced P.L. 89-306.

First, timesharing remained a strong trend during the third generation. By late 1966, almost every major computer manufacturer was marketing timesharing equipment. By 1968 the commercial provision of timesharing services had developed into a $70 million industry. However, timesharing during the 1960's was designed for and used predominately by the scientific and engineering communities. The lack of business applications was due primarily to two factors. First, the early timesharing systems experienced numerous reliability problems and businesses could not tolerate this in handling their accounting, financial, and inventory data. Secondly, the computer industry did not market the software packages needed for financial and inventory timesharing applications. However, by 1971 both these situations had been corrected and timesharing was being used extensively in countless applications. Nevertheless, timesharing did not supplant all other modes of operation as some early enthusiasts

had predicted. One reason for this was the development of the inexpensive, yet powerful, minicomputer.

The development and continual improvement of minicomputers was a second major trend during the third generation. Minicomputers are discussed separately below and thus this trend is only briefly summarized here. The PDP-8, introduced in 1965, initiated the commercial success of the minicomputer. From 1966 to 1971, minicomputer prices decreased by 20% to 30% per year, while the cost/performance ratio concurrently improved by two orders of magnitude. The cost, size, and capability improvements in minicomputers during the third generation made them increasing popular. Sales grew from 1,000 machines in 1965 to 13,500 in 1971.

A third trend during this generation was the production of families of computers in which the hardware and software was compatible. This was a continuation of the second generation trend toward integrated product lines. A family of computers is essentially a series of similar machines produced by one manufacturer. Within this series a user can change or upgrade to a larger computer with minimal effort. Thus, the series of computers is said to be compatible. An illustration of a computer family is the IBM System 360. About 20 models of the 360 family were manufactured. As an example of compatibility a user could upgrade from a 360/50 to a 360/65 over

a weekend. Concurrent with this trend toward compatibility, there emerged a number of manufacturers who specialized in producing computer components, such as disk, tape units, and other peripherals, which were plug-to-plug compatible with the major manufacturer's series of computers. These specialized third-party vendors could often undersell the major manufacturer. However, this trend toward compatibility should not be overemphasized. There was little compatibility between different manufacturer's equipment and even limited compatibility among families of computers offered by a single company. (Hollander, 1966:48; Guise, 1969:38, 39; Hittinger, 1973:51; Vacroux, 1975:33; Kaenel, 1970:12; Theis, 1971:39; Nyborg, 1978:12; Bell, 1971:561; Adams, 1973:274, 275; Frost, 1970:24; McLaughlin, 1970)

Minicomputers. Probably the most significant trend during the third generation was the continual improvements in minicomputers. While there is no precise definition of a minicomputer, certain characteristics are typical of this size of computer. Features often used to classify a computer as a minicomputer include costs, word length, size, and application. During the third generation a reasonable categorization of minicomputers would be computers--1) whose basic cost was less than $50,000, 2) with word length between 8 and 18 bits, 3) would fit in one 6 foot equipment rack, and 4) dedicated to one application.

The first embodiments of the minicomputer are generally considered to be Digital Equipment Corporation's PDP-5 and PDP-8. Based upon advances in transistor and integrated circuitry, the PDP-5 was introduced in 1963 at a price of $27,000. However, each PDP-5 was virtually handbuilt and only 100 were produced. The PDP-8 was introduced in 1965. Constructed primarily of integrated circuits, it was more powerful and smaller than the PDP-5, but cost $9,000 less. The PDP-8 was the first mass-produced minicomputer. "Nearly as powerful as much larger computers costing several times more, it was soon widely imitated. Within a decade it had given rise to an entire industry . . . . " (Vacroux, 1975:32)

With advances in integrated circuitry, minicomputers progressed significantly. From 1966 to 1971, minicomputer cost decreased 20% to 30% each year, while the cost/performance ratio improved by two orders of magnitude. To illustrate the price change during this period, a typical 16 bit minicomputer with 4K of memory cost $25,000 in 1965, $13,000 in 1968, $8,000 in 1970, and $6,400 in 1971. Using the time required to perform an addition as an illustration of capability, in 1971 the PDP-15 required 1.6 microseconds, the NOVA 1200 required 2.2 microseconds, and the RAYTHEON 706 required 1.8 microseconds. Thus, by 1971, minicomputers had performance abilities equivalent to large second generation computers at a fraction of the costs.

Despite this technological progress minicomputers were used in only limited applications until the early 1970's. "The early applications for minicomputers were primarily in instrumentation systems, test systems, control systems, and data acquisition and reduction." (Hobbs, 1974:53) Among the factors restricting the use of early minicomputers were their small memories and limited software. The maximum memory size for most of the early machines was 32K. This limited the size of their software programs and the scope of their application. Also, the operating systems on the early minicomputers were restrictive. Not until about 1967 were FORTRAN compliers developed for most minicomputers. Another factor limiting the generalized use of minicomputers was the trend toward time-sharing. However, by the end of the third generation improvements in hardware and software, coupled with continually declining prices, made minicomputers desirable in a variety of applications. This was reflected by 1971 sales of 13,500 machines. (Theis, 1969:39; Stone, 1975:137, 138, 140; Knowles, 1977:2-79; Vacroux, 1975:32, 33; Hobbs 1974:51, 53; Kaenel, 1970:12; Theis, 1971:25, 26, 29; Gannon, 1966)

Electronic Calculators. The advances in electronic circuitry that made the minicomputer possible also led to the electronic calculator. The calculator's early development was discussed previously under the origins of the computer. Calculators continued

to be constructed of mechanical gears and electric motors until the early 1960's. "It was 1963 before transistors decreased to a price that made electronic calculators practical." (Stone, 1975:82) Within a few years electronic calculators, including programmable calculators, were being manufactured by companies such as Wang, Olivetti, Friden, and Hewlett-Packard. In 1967, a Japanese company, now Sharp Company, introduced the first integrated circuit calculator. From this time until the end of the third generation, electronic calculator prices decreased by a factor of two each year. Concurrently, calculators, especially programmable calculators, became increasingly powerful. By the close of the third generation, a *Datamation* article reported that, "During the past decade, programmable calculators have grown . . . to powerful, flexible, interactive calculating systems that rival minicomputers." (Asmus, 1972:55) (Stone, 1975:82-84)

Large Computers. Advances in integrated circuitry produced progress in large computers similar to that mentioned for minicomputers and calculators. As an example, the IBM 360/195 had an instruction cycle time of 54 nanoseconds and could process up to 15 problems simultaneously. The performance capabilities of large third generation machines made it feasible and economic to apply computers to heretofore impractical problems such as global weather

forecasting, aerodynamic flow studies, and economic simulations. (Spencer, 1974:250, 251)

Computers, 1971 to 1978

The computers of 1971 to 1978 are characterized by large-scale-integrated circuitry and microprocessor technology. There is little agreement in computer literature as to the classification of this period--some authors still call it the third generation, others refer to it as the 3 1/2 generation, while yet others say the fourth generation. Regardless of the terminology one wishes to use, technological progress during this period did significantly affect the performance, cost, and size of computers.

The developments and progress in computing from 1971 to 1978 are now described. First, advances in integrated circuits are discussed. Then, the progress in microprocessors, microcomputers, calculators, minicomputers, and large computers is examined. The emphasis here is on the development and evolution of microprocessors and microcomputers. Finally, three trends which relate to P.L. 89-306 and ADPE management are briefly discussed.

Integrated Circuits, 1971-1978. The development of integrated circuitry from the early 1960's to 1971 was discussed under the third generation. By 1971, the cost of integrated circuits had decreased by a factor of 27; while concurrently the number of circuit elements

that could be placed in a single semiconductor chip had doubled every year since 1960. From the early 1960's to 1971, integrated circuits advanced from rudimentary devices containing about a dozen circuit elements to high performance, low cost, large-scale-integrated (LSI) circuits containing up to 5,000 circuit elements.

This progress in integrated circuit technology has continued unabated from 1971 to the present. During these seven years, the number of circuit elements in a single chip has continued to double each year. Integrated circuit chips containing 2^{18} (262, 144) elements are now available. This translates into computer logic circuits containing 20,000 to 30,000 transistors (each transistor consists of several circuit elements) and semiconductor memory chips containing close to 100,000 transistors. Since integrated circuit fabrication is a batch production process, placing more components in a chip results in decreased costs. Computer logic gate costs have declined to about one cent per gate in LSI logic circuits. Similarly, the cost per bit of random access memory (RAM) has declined approximately 35% per year since 1970. Today, a semiconductor RAM circuit with 16,384 bits storage capacity can be purchased for thirty dollars, a cost of less than $0.002 per bit. In addition to decreased costs, the higher density of components on a chip also results in increased speed. From 1971 to 1978, the propagation delay of a typical commercial logic circuit decreased from 5 nanoseconds to 3

nanoseconds, a 40% improvement. Overall, from 1971 to the present, integrated circuit performance continued to improve while the cost of integrated circuits continued to decline. (Noyce, 1977:65, 67; Holton, 1977:94, 95; Hughes Aircraft Company, 1977:243; Mayo, 1977:192; Bloch, 1978:64; Terman, 1977:171)

Microprocessors and Microcomputers. Progress in electronic circuitry, particularly advances in large-scale-integrated circuits, resulted in development of microprocessors and microcomputers.

> A microprocessor is the central arithmetic and logic unit of a computer, together with its associated circuitry, scaled down so that it fits on a single silicon chip (sometimes several chips) holding tens of thousands of transistors, resistors, and similar circuit elements. It is a member of the family of large-scale integrated circuits that reflect the present state of evolution of a miniaturization process that began with the development of the transistor in the late 1940's. (Toong, 1977:146)

As the above statement indicates, microprocessors were a natural outgrowth of transistor and integrated circuit technology. As large-scale-integration progressed it was inevitable that the entire central processing unit (CPU) of a computer would be placed onto one integrated circuit chip. In 1971, Intel Corporation introduced the first commercially available microprocessor, the Intel 4004. The 4004 combined 2,250 transistors on a chip about .17 inches long and .12 inches wide. This one chip could perform as the CPU for a computer.

A microcomputer is a general purpose computer system built around a microprocessor CPU. A microcomputer is formed by adding typically from 10 to 80 chips to a microprocessor CPU to provide timing, memory, and input/output interfaces. This entire computer system can generally be assembled on a single circuit board about six inches square. Thus, a microcomputer is essentially a standard computer system distinguished by its small size and the use of a microprocessor for its central processing unit.

In only seven years, microprocessors and microcomputers have advanced from the relatively basic Intel 4004 to microcomputers that rival higher-level minicomputers in performance. Because of their innate relationship, progress in microprocessors and microcomputers will be described concurrently. Microprocessors are usually classified according to their word length. The early machines, such as the Intel 4004 and Rockwell PPS-4, had four bit words. These first four-bit microprocessors were inexpensive, the 4004 sold for $30, but were slow with instruction execution times of five to twenty microseconds. These microprocessors were used directly in calculators and other dedicated applications. Also, they were used as building blocks which were cascaded to form 8-, 12-, 16-, and even 32-bit microcomputers. The resultant longer word length provided higher throughput and easier programming.

Eight-bit microprocessors were introduced by Intel in 1972.

By 1975, they had become the most popular class of microprocessors, "Probably the most useful advantage of 8-bit chips is the additional storage capacities (65 K bytes vs. 16 K bytes for the 4-bit chips)." (Theis, 1974:91) Other benefits included improved addressing operations, more instructions, more versatile register stack operations, and vectored interrupts. As a result of these improvements, microprocessors and microcomputers had more computing power, more flexibility, and a ten times increase in speed.

By 1975, several twelve and sixteen-bit microprocessors had been introduced. Some of these were " . . . highly integrated versions of previously available minicomputers, for which they are an economic substitute when speed is not critical." (Vacroux, 1975:35)

About twenty different microprocessors and microcomputers were being marketed by 1975. These machines had a typical instruction execution time of 2 microseconds, random access memory of up to 512 K bits, and software ranging from 8 to 100 instructions. The cost of microprocessors at this time was from about $40 to $600 and microcomputer cost ranged from $200 to $2500. Thus, by 1975, microcomputer's cost and capabilities were making them competitive with small minicomputers.

From 1975 to the present, microprocessor and microcomputer capabilities continued to increase, primarily due to advances in

integrated circuit technology. One area of significant progress was microprocessor operating speed. The typical cycle time decreased from 2 microseconds to less than half a microsecond. This made microcomputer speeds comparable to those of minicomputers. In fact, Zilog Corporation's Z8000 16-bit microcomputer " . . . has in many cases a higher throughput than the Digital Equipment Corp. PDP-11/45, itself near the top of the minicomputer range." (Faggin, 1978:29) Another result of progress in integrated circuits was the single-chip microcomputer. With the number of circuit elements possible on one semiconductor chip doubling each year, more microcomputer features could be placed on one integrated circuit. Inevitably, the main functions of a microcomputer were combined on one LSI circuit. An example of this is the Intel 8748 which occupies a 5.6 by 6.6 millimeter chip.

> The device combines a microprocessor, which would ordinarily occupy an entire chip, with a variety of supplementary functions such as program memory, data memory, multiple input/output interfaces and timing circuits. (Toong, 1977:147)

During the last three years, the prices of microprocessors and microcomputers have declined. As of February, 1978, an Intel 8080 microprocessor could be purchased for $7.10 in quantities of 100 or more. The prices of microcomputers vary depending on such items as peripherals; but, a complete computer system, such as the TRS-80, can be purchased for as little as $600.

The performance, cost, and size of microprocessors and microcomputers make these machines practical for a wide variety of applications. One of the most basic and common applications is the replacement of inflexible, hard-wired circuitry with a microprocessor. Examples of this use are calculators, watches, alarms, television sets, washing machines, dishwashers, refrigerators, electronic test equipment, point of sale systems, automobiles--the list is virtually endless. In this type application, the microprocessor software logic essentially replaces the hard-wired logic of numerous fixed circuits. Typical cost saving range from 40% to 80%. Other advantages include up to a two-thirds reduction in design time and increased flexibility for re-design. Currently, this use of microprocessors is cost effective when at least 30 hard-wired circuits can be replaced. Microprocessors and microcomputers are also being used as part of larger computer systems. Often they are incorporated as controllers in perpherial equipment, thus making these units semi-independent of the main central computer. Also, microcomputers may be used as part of a distributed processing system, thereby functioning autonomously or in conjunction with a larger computer. Finally, microcomputers are powerful enough to serve as stand-alone computers for many applications. Examples are industrial process control, machine-tool control, small business accounting and inventory applications, and many personal or home uses. "The

potential applications of microprocessor technology are so numerous that it is hard to visualize any aspect of contemporary life that will escape its impact." (Toong, 1977:160) (Toong, 1977:146, 147, 160; Vacroux, 1975:34, 35; Faggin, 1978:28; Theis, 1974:90, 91, 96-98; Yasaki, 1974:83, 86; Hardware, 1978:208; TRS-80 Microcomputer System Products, 1978:2; Petritz, 1977:23, 24; Sippl, 1977:viii)

Calculators. In the last seven years, calculators have become increasingly sophisticated and powerful, primarily due to advances in LSI and microprocessor technology. It is now very difficult to distinguish between calculators and microcomputers. "The most reasonable dividing line between calculators and computers seems to be the degree of generality for which the machine is designed." (Pittman, 1977:109) Calculators tend to be more limited in input/output, less flexible, and usually dedicated to a particular class of problems.

Today, calculators range from commercial office and laboratory units to pocket-size versions. Current large commercial calculators can be programmed with up to 32,000 instruction steps; applications include sales, marketing, accounting, and operations research. As mentioned above, it is increasingly difficult to differentiate these units from computers. Progress in calculator technology is most evident in pocket calculators. In 1971, MOSTEK Corporation and Busicom announced the first single chip integrated circuit calculator.

Early models of the single chip calculator sold for $395. By 1973 an equivalent calculator sold for $39.50. In 1974 Hewlett-Packard introduced the first programmable pocket calculator, the HP-65. It could execute up to 100 step programs which were recorded on magnetic cards. In 1975, Texas Instrument announced the SR-52. It had 20 addressable data registers and could execute 224 program steps with 2 levels of subroutines. The SR-52 currently sells for $300. In 1977 Texas Instrument announced the TI-59. It has all the features of the SR-52 and additionally utilizes plug-in Read-Only-Memories (ROMs) which offer 40,000 bits of storage. The ROM permits up to 5000 program steps. The TI-59 sells for $250 with an optional desk-top thermal printer unit. Pocket calculators are also available in non-programmable versions. The most basic of these sell for under $10. Overall, calculators are now available in a wide range of cost and performance. (Pittman, 1977:109, 112, 113; Asmus, 1972:55; Wells, 1976:18; Sippl, 1977:100)

<ins>Minicomputers</ins>. The technological progress of the last seven years has also impacted minicomputers. These machines have become more powerful and less expensive. Their performance capabilities have increased such that " . . . the minis are eroding the domain of the medium--and large-scale systems." (Sippl, 1977: viii) Basic minicomputer systems are generally priced in the $15,000

to $25,000 range. However, some systems sell for $5,000 to $10,000 and a few cost as little as $1,000.

Increasing performance and decreasing cost have expanded minicomputer applications. Networks of minicomputers can now be used to replace complex, large computers. Advantages of these networks include less risk of systems breakdown, availability, economy of operation, flexibility to fit organizational philosophy, and less complexity of system design and implementation. Minicomputers are also being used in applications where they were previously not economical. One example of this is computerized word processing systems.

> The minicomputer, when used for word processing, is extremely flexible. It can handle complex editing changes including bulk paragraph movement, massive format rearrangements, multiple user support, a variety of output media and a huge storage capacity. (Austreich, 1973:16)

As an illustration of the possible benefits, one public utility saved over $200,000 in labor costs alone the first year they installed a word processing system. The price of word processing systems begins at less than $5,000.

The expansion in minicomputer applications is exemplified by the increased number of minicomputer installations in the United States. In 1970, there were 24,500 minicomputers in use. By 1975 this number had increased to 137,000. (Sippl, 1977:viii, 76; Kanter, 1977:36, 262; Austreich, 1973:16; Burns, 1977:62)

Large Computers. Advances in large-scale-integrated circuitry have made possible continuing speed and performance improvements in large computers. This has made the traditional uses of large machines more efficient and has also opened new application areas to computer assistance. As an illustration, one area in which computer capabilities are just now reaching adequate levels to be economically beneficial is aerodynamic simulation. However, it is estimated that to economically simulate the flow fields around practical airplane wing-body configurations would require a computer at least 100 times more powerful as any available in 1978. Thus, progress in small computers is not resulting in the demise of large computers; rather, the same technological advances are making large computers practical for new and more complex applications. (Elson, 1978:125)

Trends. The writer will now briefly discuss three trends within the 1971-1978 period which relate to P.L. 89-306 and ADPE management. The first of these is decentralization. From the early 1950's to the early 1970's centralization--with timesharing as a corollary--had been a prevailing trend. The concept was that if the work of many small computers could be consolidated into one large computer, then total cost could be lowered. However, "The trend toward centralization has stopped." (Patrick, 1976:79) While there are many reasons for this, two of the major factors are decreasing computer prices and increasing complexity in large-scale operations.

> Needless to say, customers of complex systems are an unhappy lot. They have learned to expect scheduled work late, crashes in the middle of the day, supposedly transparent changes that affect them, and frequent reorganizations in the computer shop. (Patrick, 1976:80)

Decreasing prices of minicomputers, microcomputers, and calculators made it feasible to provide users with decentralized computing devices. Decentralization--forms of which are termed distributed computing, distributive data processing, and network computing--offers advantages such as increased reliability, improved availability, more flexibility, and faster response or turnaround. Currently, the prevailing trend in data processing seems to be toward decentralization.

The second trend to be discussed is timesharing. As covered earlier, timesharing was a major trend during most of the 1960's. In fact, an early enthusiast predicted that timesharing would replace all other modes of operation. Ironically, by 1976, the trend had shifted such that an article in Popular Computing predicted, "The time-sharing industry will die by late 1978." (Hardware, 1976:134) Obviously, neither prediction has come true. Timesharing is still widely used. As one of many alternative forms of computing, timesharing meets the needs of many users.

Compatibility is the final issue to be discussed. This trend began in the early 1960's and has been furthered by production of

families of computers. Today, manufacturers still produce compatible families of computers and third-party vendors still offer plug-to-plug compatible components. However, there seems to have been only limited increases in compatibility during the last seven years. Progress has been particularly slow in the adoption of standards among manufacturers. Manufacturers such as IBM claim that standardization would impede technological progress. Other parties, such as the Computer Industry Association, indicate the manufacturers' opposition to standards is to avoid increased competition. (Gruenberger, 1973:viii; Patrick, 1976:79, 80; Wohl, 1977:68; Sippl, 1977; Hirsch, 1976:114)

The Future

> The cost/performance ratio of data processing hardware has improved by a factor of 100 each decade since 1955, and all of the indications and available data suggest that this will continue for at least the next decade. (Nyborg, 1978:48)

A brief overview of predictions on the future of computing is now presented. First, the basic technologies, primarily integrated circuitry, are discussed. Then the expected progress in computers themselves is described.

Since about 1965, improvement in integrated circuitry has been the major factor in computer progress. Evolutionary advances in integrated circuitry seem likely to continue in the near future. As

mentioned previously, the number of circuit elements that can be placed on one integrated circuit chip has been doubling each year for the past 18 years; this process shows no signs of slowing down in the next few years.

> The prospects for this next generation of very-large-scale integrated circuits (VLSI) are extraordinary. A processor would take up a trivial protion of such a chip; millions of bits of memory could be included as well. (Holton, 1977:94)

Also, the speed of integrated circuitry can be expected to increase. Hughes Aircraft Company has already tested circuits with delays of 170 picoseconds (a picosecond is 1×10^{-12} seconds or one-millionth of a microsecond). Furthermore, the cost of integrated circuitry should continue to decline. The cost of a logic gate on a LSI circuit is expected to decrease from one cent today to .1 cent by the early 1980's.

Other technologies that may affect computers in the next 5-10 years are Josephson junctions, charged-coupled devices (CCD), and magnetic-bubble memory. The concept of the Josephson junction is that at temperatures close to absolute zero electrons can move or tunnel through circuitry with almost no resistance. The amount of current in such a device would be infinitesimally small; thus, less heat would be generated and the circuitry could be more compact. The result would be faster speeds. "By the late 1980's, IBM

scientists envision tiny computers, refrigerated inside tanks of liquid helium, that operate a hundred times as fast as today's machines." (The Age of Miracle Chips, 1978:58) Charged-coupled devices (CCD) and magnetic-bubble memory are two types of computer memory elements developed by Bell Laboratory. The CCD stores packets of electrical charge, representing information, in movable chains. CCDs are now available that can store up to 64,000 bits on one chip. In magnetic-bubble memory, microscopic bubbles of magnetism are used to code information. Experimental bubble memories containing 250,000 bits have been constructed. CCDs and bubble memory may expedite the trend toward decentralization. "The ability to distribute computer power as needed has been made possible by the emergence of low-cost minicomputers, microprocessors, and semiconductor memories." (Toombs, 1978:38) CCD and bubble memory offer the low cost storage needed for small computers, portable terminals, and even calculators.

As a result of technological advances, the cost/performance ratio of computers is expected to increase by a factor of 100 in the next decade. The progress in small computers during the last seven years will continue unabated.

> By 1985, according to C. Lester Hogan, vice chairman of Fairchild Camera and Instrument Corp., it will be feasible to build a pocket calculator 'that will be more powerful than, and almost as fast

> as, ' the $9 million Cray-1 built by Cray Research Inc. in Chippewa Falls, Wis., and recognized as the mightiest computer in the world. (The Age of Miracle Chips, 1978:51)

This technological progress can be expected to produce increasing capabilities across the entire computing spectrum--from pocket calculators through large-scale computers. "Warns William Howard, Motorola's director of strategic operations: 'Our biggest problem is going to be finding ways of transforming all this innovation into viable products that are simple to use.'" (The Age of Miracle Chips, 1978:51) During the last few years the decreasing cost of computers has made it economical to incorporate them into basic applications such as word processing, automobiles, and ovens. Concurrently, increasing performance has made computers applicable to more sophisticated, complex problems such as aerodynamic modeling. Both of these trends can be expected to continue in the next decade with large computers and small computers used in an everwidening range of applications. For example, Lee Williams of Bell Laboratories states: "Applications of the microprocessor five years from now will make the present ones look silly." (The Age of Miracle Chips, 1978:51)

What will be the eventual role of the computer?

> Dartmouth President John Kemeny, a pioneer in computer usage, sees the ultimate relation between man and computer as a symbiotic union of two living species, each completely dependent on the other for survival. (Jastrow, 1978:59)

According to Robert Jastrow, director of NASA's Goddard Institute for Space Studies, "In another 15 years or so--two more generations of computer evolution, in the jargon of the technologists--we will see the computer as an emergent form of life." (Jastrow, 1978:59) (Nyborg, 1978:48; Holton, 1977:94; Hughes Aircraft Company, 1977: 243; The Age of Miracle Chips, 1978:51, 58; Toombs, 1978:38; Jastrow, 1978:59)

Chapter Summary

This chapter presents an overview of computer progress from the earliest computing devices through the present and projects this progress a decade into the future. The writer's objective is to illustrate the growth and changes in the computer field with emphasis on the progress since the early 1960's when P.L. 89-306 was first proposed.

The modern computer resulted from the convergence in the late 1930's of many diverse technological developments. World War II provided the stimulus for government financing of computer research. The early electromechanical and electronic computers were developed as part of World War II projects. Progress during this period was primarily in computer organization and architecture culminating in the von Neumann concepts. During the 1950's, computers became commercially successful.

As stated above, the emphasis of this chapter begins with the second generation of computers. Based on transistor technology, second generation computer performance and reliability increased while the relative cost and size of computers decreased. It was during this period that P.L. 89-306 and the basic groundrules of the ADP management structure were formulated. Several computer trends, primarily timesharing and compatibility were evident during this time.

The evolution of small-scale ADPE began with integrated circuitry and the third computer generation. Integrated circuits offered the lower cost, increased speed, and smaller size needed to make small computers successful. The minicomputer originated during this period with the introduction of the PDP-8 in 1965. From 1966 to 1971, minicomputer prices declined 20% to 30% each year, while the cost/performance ratio improved by two orders of magnitude in those 5 years. Again, certain trends relative to ADP management --timesharing, compatibility, and minicomputers--were evident.

From 1971 to the present, small-scale ADPE continued to evolve. In 1972, microprocessors and microcomputers became commercially available. In the following six years these machines improved to where they now rival top-line minicomputers. The progress in microcomputers during this time has greatly expanded the

spectrum of applications for computers.

In the next ten years, technological advances are expected to improve the cost/performance ratio of computers by a factor of one hundred.

III. Public Law 89-306: The Foundation of the ADP Management Program

Automatic data processing management in the federal government is founded on Public Law 89-306. This law provides the basic structure and concepts for the government-wide system of ADP management. It is implemented within the Air Force by the 300-series of regulations. An examination of P.L. 89-306 is a prerequisite to investigating the acquisition and management of small-scale ADPE under the Air Force regulations.

This chapter has two purposes. The first is to provide an overview of P.L. 89-306 and the ADP management structure that it established. The second purpose is to address a specific subobjective of this thesis research: determine if the ADP management program was founded on any particular technological assumptions. Then, having made an affirmative determination, the effect of these assumptions on ADP management is discussed. Throughout this chapter frequent reference is made to Senate Report No. 938. This report accompanied P.L. 89-306 through Congress and provides a legislative history of the law.

Public Law 89-306: An Overview

This overview of P.L. 89-306 is organized into three sections. First, background information is presented which illustrates the problems and events which led to Congressional action. Then the text of the law is reproduced. Finally, the management structure that P.L. 89-306 established and the responsibilities it assigned are discussed.

Background. P.L. 89-306 was passed by Congress in 1965 to correct the pervasive mismanagement of automated data processing equipment (ADPE) in the federal government. As governmental computer usage increased during the 1950's, management policies applicable to calculators and office equipment were applied to ADPE. Between 1958 and 1965, the Comptroller General submitted more than 100 audit reports to Congress showing a pattern of ADPE mismanagement. "From the standpoint of the government as a whole the situation was very bad." (Baynard, 1976:32) Government agencies acquired computers independently without regard to government-wide needs and available capacities. There was little computer sharing between agencies and many computers were under utilized. Because of independent agency acquisitions, the government did not receive any volume price discounts on its purchases although it was the largest computer user in the world. Lease/purchase evaluations were done on an agency basis instead of a government-wide basis

resulting in widespread leasing where purchasing would have been better. In view of such problems both the Executive and Legislative branches recognized the need for improvements in ADP management.

As early as 1959, a Bureau of the Budget (BOB) study ". . . recognized the need for specialized management of ADP, for Government-wide coordination, and for accurate up-to-date information for all levels of management." (Senate Report No. 938, 1965:3861) Within the Legislative branch, the General Accounting Office (GAO) submitted ADP management studies to Congress in 1958, 1960, 1963, and 1964. These studies recommended government-wide coordination in ADP management. Despite these recognized problems, little action was taken by the Executive branch beyond the issuance of advisory guidelines. In Congress, the House Government Activities Subcommittee under Chairman Jack Brooks held hearings on federal ADPE management in 1963 and 1965. The outgrowth of these hearings was the passage of Public Law 89-306, commonly known as The Brooks Act, in October 1965. (Senate Report No. 938, 1965: 3859-3890; Baynard, 1976:28-38)

Public Law 89-306. Public Law 89-306 was enacted by Congress on October 30, 1965. The law amended Title I of the Federal Property and Administrative Services Act of 1949 by adding a section to cover automatic data processing equipment. The Federal Property and Administrative Services Act of 1949 established the General

Services Administration (GSA) and the "Administrator" referred to in P.L. 89-306 is the Administrator of GSA. The text of P.L. 89-306 is reproduced below.

[Brooks Bill]

AUTOMATIC DATA PROCESSING EQUIPMENT

PUBLIC LAW 89-306; 79 STAT. 1127

[H.R. 4815]

An Act to provide for the economic and efficient purchase, lease, maintenance, operation, and utilization of automatic data processing equipment by Federal departments and agencies.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That:

Title I of the Federal Property and Administrative Services Act of 1949 (63 Stat. 377), as amended, is hereby amended by adding a new section to read as follows:

"AUTOMATIC DATA PROCESSING EQUIPMENT

"Sec. 111. (a) The Administrator is authorized and directed to coordinate and provide for the economic and efficient purchase, lease, and maintenance of automatic data processing equipment by Federal agencies.

"(b) (1) Automatic data processing equipment suitable for efficient and effective use by Federal agencies shall be provided by the Administrator through purchase, lease, transfer of equipment from other Federal agencies, or otherwise, and the Administrator is authorized and directed to provide by contract or otherwise for the maintenance and repair of such equipment. In carrying out his responsibilities under this section the Administrator is authorized to transfer automatic data processing equipment between Federal agencies, to provide for joint utilization of such equipment by two or more Federal agencies, and to establish and operate equipment pools and data processing centers for the use of two or more such agencies when necessary for its most efficient and effective utilization.

"(2) The Administrator may delegate to one or more Federal agencies authority to operate automatic data processing equipment pools and automatic data processing centers, and to lease, purchase, or maintain individual automatic data processing systems or specific units of equipment, including such equipment used in automatic data processing pools and automatic data processing centers, when such action is determined by the Administrator to be necessary for the economy and efficiency of operations, or when such action is essential to national defense or national security. The Administrator may delegate to one or more Federal agencies authority to lease, purchase, or maintain automatic data processing equipment to the extent to which he determines such action to be necessary and desirable to allow for the orderly implementation of a program for the utilization of such equipment.

"(c) There is hereby authorized to be established on the books of the Treasury an automatic data processing fund, which shall be available without

fiscal year limitation for expenses, including personal services, other costs, and the procurement by lease, purchase, transfer, or otherwise of equipment, maintenance, and repair of such equipment by contract or otherwise, necessary for the efficient coordination, operation, utilization of such equipment by and for Federal agencies: *Provided*, That a report of equipment inventory, utilization, and acquisitions, together with an account of receipts, disbursements, and transfers to miscellaneous receipts, under this authorization shall be made annually in connection with the budget estimates to the Director of the Bureau of the Budget and to the Congress, and the inclusion in appropriation acts of provisions regulating the operation of the automatic data processing fund, or limiting the expenditures therefrom, is hereby authorized.

"(d) There are authorized to be appropriated to said fund such sums as may be required which, together with the value, as determined by the Administrator, of supplies and equipment from time to time transferred to the Administrator, shall constitute the capital of the fund: *Provided*, That said fund shall be credited with (1) advances and reimbursements from available appropriations and funds of any agency (including the General Services Administration), organization, or contractor utilizing such equipment and services rendered them, at rates determined by the Administrator to approximate the costs thereof met by the fund (including depreciation of equipment, provision for accrued leave, and for amortization of installation costs, but excluding, in the determination of rates prior to the fiscal year 1967, such direct operating expenses as may be directly appropriated for, which expenses may be charged to the fund and covered by advances or reimbursements from such direct appropriations) and (2) refunds or recoveries resulting from operations of the fund, including the net proceeds of disposal of excess or surplus personal property and receipts from carriers and others for loss of or damage to property: *Provided further*, That following the close of each fiscal year any net income, after making provisions for prior year losses, if any, shall be transferred to the Treasury of the United States as miscellaneous receipts.

"(e) The proviso following paragraph (4) in section 201(a) of this Act and the provisions of section 602(d) of this Act shall have no application in the administration of this section. No other provision of this Act or any other Act which is inconsistent with the provisions of this section shall be applicable in the administration of this section.

"(f) The Secretary of Commerce is authorized (1) to provide agencies, and the Administrator of General Services in the exercise of the authority delegated in this section, with scientific and technological advisory services relating to automatic data processing and related systems, and (2) to make appropriate recommendations to the President relating to the establishment of uniform Federal automatic data processing standards. The Secretary of Commerce is authorized to undertake the necessary research in the sciences and technologies of automatic data processing computer and related systems, as may be required under provisions of this subsection.

"(g) The authority conferred upon the Administrator and the Secretary of Commerce by this section shall be exercised subject to direction by the President and to fiscal and policy control exercised by the Bureau of the Budget. Authority so conferred upon the Administrator shall not be so construed as to impair or interfere with the determination by agencies of their individual automatic data processing equipment requirements, including the development of specifications for and the selection of the types and configurations of equipment needed. The Administrator shall not interfere with, or attempt to control in any way, the use made of automatic data processing equipment or components thereof by any agency. The Administrator shall provide adequate notice to all agencies and other users concerned with respect to each proposed determination specifically affecting them or the automatic data processing equipment or components used by them. In the absence of mutual agreement between the Administrator and the agency or user concerned, such proposed determinations shall be subject to review and decision by the Bureau of the Budget unless the President otherwise directs."

Approved October 30, 1965.

Analysis. The stated purpose of P.L. 89-306 is ". . . to provide for the economic and efficient purchase, lease, maintenance, operation, and utilization of automatic data processing equipment by Federal departments and agencies." The intent of Congress was "To achieve a businesslike Government-wide coordinated management effort . . . " by providing a "delineation of responsibilities and stronger organizational plan for Government ADP management . . . ." (Senate Report No. 938, 1965:3877) Thus, P.L. 89-306 did not establish specific procurement or administrative policy. Rather, it set up a centralized ADP management structure in the Executive branch and assigned responsibilities for providing ADP management.

P.L. 89-306 designated three agencies within the Executive branch to provide government-wide ADP management. Particular responsibilities were assigned to the Bureau of the Budget--since renamed the Office of Management and Budget (OMB), the General Services Administration (GSA), and the Department of Commerce which delegated its duties to the National Bureau of Standards (NBS). Also, certain responsibilities were left with the agencies which utilize ADPE, hereafter referred to as the user agencies.

The centralization of ADP management authority in GSA is the most significant feature of P.L. 89-306. The GSA Administrator was given jurisdiction over the acquisition, maintenance, and

utilization of ADPE in all federal agencies. The purchase and lease of ADPE was centralized in GSA. Senate Report No. 938 indicates that GSA was to become the "single purchaser" of ADPE for the entire government. This would put the government in a strong bargaining position, provide for volume discounts, and ensure a competitive environment among ADP manufacturers. Likewise, maintenance of government ADPE would be provided at the most competitive price possible. An exception to this centralized procurement is allowed by paragraph (b)(2) of the law. It permits GSA to delegate the lease, purchase, or maintenance of individual ADP systems to the user agency when necessary for reasons of economy, efficiency, national security or national defense.

GSA was also assigned responsibility for the efficient and effective utilization of ADPE. The law authorized three methods to accomplish this. GSA can fill an agency's request for equipment by providing unused time on under utilized hardware. Alternatively, GSA can transfer ADPE between agencies to increase utilization. Finally, inter-agency equipment pools and data processing centers can be established when necessary for efficient utilization.

To finance GSA's government-wide ADP program, a revolving fund was established. Essentially, the funds the user agencies had been receiving from Congress for ADPE would go into this fund. These monies would be available without fiscal year limitations.

In summary, GSA was assigned the operational responsibility for coordinating government ADP management. Basically, GSA was to make procurement, maintenance, and utilization decisions on a government-wide basis whereas previously these decisions were made independently by the various agencies.

P.L. 89-306 assigned the technical aspects of the ADP management system to the National Bureau of Standards (NBS). The law assigned the NBS two duties. The first was a general function of providing technical advisory services to GSA and the user agencies. The second responsibility was more specific and more significant. The NBS was charged to develop uniform ADP standards for the federal government. Senate Report No. 938 states that "Among the more serious problems confronting the Government in ADP utilization is the lack of compatibility in equipment." NBS was authorized to work with the ADPE manufacturers in a standardization effort.

Both NBS and GSA were to exercise their authority under the fiscal and policy control of OMB. This was basically a reaffirmation of the role of OMB as a staff office of the President. Senate Report No. 938 specifically points out that OMB is given policy responsibilitity, not operational responsibility--"The assumption of operational responsibilities . . . could hamper [OMB's] ability to fulfill its primary mission as a staff office of the President dealing with policy and fiscal matters." (Senate Report No. 938, 1965:3875) Thus, OMB

was assigned policy and fiscal responsibilities for ADP, GSA was assigned operational responsibilities, and the NBS was assigned technical responsibilities.

P.L. 89-306 also left certain responsibilities with the user agencies which had to work through this centralized ADP management system. The agencies retained the right to determine their own ADPE requirements including the development of specifications and the selections of the types and configurations of equipment needed. Furthermore, the user agencies retained control of the use of their ADPE. Any disagreement between the agencies and GSA could be appealed to OMB.

In summary, P.L. 89-306 established a government-wide ADP management system within the Executive branch. OMB was assigned responsibility for policy and fiscal matters. GSA was assigned operational responsibility for ADPE procurement, maintenance, and utilization decisions. NBS was assigned the technical aspects of ADP management. Finally, the user agencies retained certain management responsibilities. The purpose of this ADP management system was " . . . to provide for the economic and efficient purchase, lease, maintenance, operation, and utilization of automatic data processing by the Federal departments and agencies." (P.L. 89-306; Senate Report No. 938, 1965:3861, 3877-3885; Baynard, 1976:32; Hirsch, 1965:45)

Was the ADP Management System Founded on Any Particular Technological Assumptions?

The possibility that the ADP management system might be founded on certain technological assumptions was suggested to this writer by a 1977 Government Executive article on ADP procurement. The article stated that "The basic groundrules were written in 1965 around 1965 technology." (The Federal ADP Procurement Maze, 1977:49) Yet, upon first examination P.L. 89-306 does not appear to involve any technical aspects of ADPE. However, upon reviewing the legislative history of the law, as presented in Senate Report No. 938, it does indeed appear that one of the fundamental concepts of P.L. 89-306 and the ADP management system was founded on certain technological assumptions. This concept was the centralization of operational procurement and management authority. The technical assumptions behind this concept were 1) the extensive use of large, centralized computers and timesharing, and 2) ADPE compatibility and standardization among manufacturers.

A review of Senate Report No. 938 illustrates how these assumptions supported the rationale of centralization. The Senate Report published in 1965, describes the type of ADPE expected in the third computer generation.

> With the arrival of third generation ADP equipment, communications systems will link large, fast, high-capacity data processing systems to offices and laboratories of numerous users.

> These users, instead of acquiring an ADP system or visiting an ADP service center, will feed problems or information to be processed into the central computer system over a communications system. The user will have installed in his office or laboratory an input-output component no more conspicuous than commonly used teletype units found in business offices throughout the world . . . . The potentials of the larger computers now in the offering which can be integrated with communications is so great that full utilization of one system's maximum capability is sufficient to fit the needs of scores of potential users . . . . As third generation time sharing increases, the traditional agency-by-agency structure of the Government in terms of ADP management, will become less apparent and less important. (Senate Report No. 938, 1965:3869, 3870)

The above quotation shows that the ADP planners expected the widespread use of centralized computers and timesharing in the third generation. Each of these centralized machines would serve many users. The significance of this assumption is that a relatively few large computer systems could logically and reasonably be centrally procured and managed. What the planners failed to foresee was the advent of the minicomputer and microcomputer and the introduction of thousands of these machines into a centralized system designed for a relatively few large timesharing computers.

Assumptions about ADPE compatibility and standardization also logically supported centralization. Senate Report No. 938 describes computer systems as being made up of "mass produced components" that are "plugged together." From these components "ADP systems

are 'configured' . . . to meet the requirements of a particular user." (Senate Report No. 938, 1965:3866, 3867) If ADP components were standardized and compatible among manufacturers, then the government could bargain with computer companies for volume acquisition of these components. The Report noted that "lack of compatibility in equipment" was a "serious problem." In recognition of this problem, the NBS was expressly tasked to represent the government in a standardization effort with the ADP manufacturers. The assumption that standardization and compatibility of ADPE components would therefore increase, logically led to the centralized procurement of these components from which general-purpose ADP systems could be configured.

Finding. A fundamental concept of the ADP management system--centralization--was founded to a significant degree on two technological assumptions. These assumptions were 1) the extensive use of large, centralized computers and timesharing, and 2) ADPE compatibility and standardization. Under the assumptions that the government would need to procure only a relatively few large computer systems and that the components of these systems would be compatible, the centralization of procurement and management authority was logical. This centralization concept established by P.L. 89-306 has influenced ADP management throughout the government. In the Air Force, for example, the purchase of ADPE, with

some exceptions, requires approval of HQ USAF.

Were the Assumptions Fulfilled?

Having concluded that the centralization concept of ADP management was based on certain technological assumptions, an examination is now appropriate as to whether these assumptions have been fulfilled. This question requires a review of computer history. Such a review was accomplished in Chapter Two of this thesis and only a brief summary is presented here.

When P.L. 89-306 was first introduced in Congress in 1963, timesharing and compatibility were significant trends in the computer field. The timesharing type of computer system did develop during the third computer generation and is still widely used. However, two other types of computer systems also developed--the minicomputer and the microcomputer. The low cost and high performance of these small-scale machines made them very popular. For example, by 1976 a single government agency, the Energy Research and Development Administration, operated about a thousand minicomputers. The cost, convenience, and capabilities of this small-scale ADPE have resulted in the present trend toward decentralized or distributed computer operations rather than large, centralized, timesharing facilities. Also, the standardization and compatibility effort initiated by P.L. 89-306 has achieved only limited success. A 1976 House

Government Operations Committee report stated "NBS has failed to provide the necessary hardware and software standards." (House Report No. 94-1746, 1976:3) As a result, " . . . the dp [data processing] standards program has failed to make system components transferable." (Hirsch, 1976:111) Many explanations may be found in the literature for this failure to achieve standardization of ADPE components. Some authors blame NBS; others criticize the computer manufacturers; still others cite the rapid evolution and technological advances in ADPE during the past thirteen years as a factor inhibiting standardization. Regardless of the reason, compatibility and standardization of ADPE have attained only limited success. Thus, the two technical assumptions upon which the centralization concept of ADP management was founded have not been fulfilled.

The Affect on ADP Management

In a system as complex as government-wide ADP management, it would be simplistic to blame current problems solely on these technological miscalculations. However, this writer does hypothesize that these changes in computer technology have contributed significantly to some of the problems. It is not within the scope of this chapter to identify and analyze current ADP management problems; this is accomplished in later chapters. Rather, the purpose here is simply to illustrate the affect of the timesharing and standardization

assumptions going unfulfilled. This is done by examining one of the most significant problems in ADP management today--time delays in ADP acquisitions.

The limited success of the standardization effort and the shift in trends from timesharing to distributed small computers have resulted in the introduction of thousands of low cost, non-standardized, small-scale ADPE items into a system originally designed for centralized management of a relatively few large computer systems. One of the most significant problems resulting from this is delays in ADPE acquisitions.

The literature search and interviews conducted as part of this thesis investigation indicate that acquisition delays are a problem and that centralized management and outdated regulatory requirements are a causal factor. The most common complaint voiced during the interviews was the length of time required for ADPE acquisitions that could not be approved locally. Some respondents spoke of HQ USAF approvals taking up to several months. Particular frustration was expressed about small-scale ADPE items which only slightly exceeded the local approval limits. A 1976 GAO report concerning minicomputers provides further evidence that the introduction of small-scale ADPE into a management system not designed for it is resulting in acquisition delays.

> Agency personnel told us that intolerable procurement delays were resulting from their own internal documentation requirements as well as from GSA's documentation requirements. Most of these requirements were developed before minicomputers appeared on the scene. In a survey of 149 installations, 39 percent said they experienced unreasonable delays in acquiring and/or implementing the minicomputers. (Report to the Congress by the Comptroller General of the United States, 1977:19, 20)

The contention that a large number of low cost acquisitions are slowing down the system is also supported by a 1976 Congressional report. The report states that a review of GSA procurement delegations made in fiscal year 1975 indicated that 56 percent of all such delegations were for procurements of $250,000 or less. Most of these acquisitions were minicomputers, peripherals, software, and maintenance. The report states that " . . . the resources of user agencies have been unfairly taxed by their being required to follow the same procedures for small dollar items as they must for major procurements." (House Report No. 94-1746, 1976:12) Thus, as a result of the timesharing and standardization assumptions going unfulfilled, ADP management has been affected.

Chapter Summary

Automatic data processing in the federal government is founded on P.L. 89-306. This law provides the basic structure and concepts for the government-wide system of ADP management. P.L. 89-306

was passed by Congress in 1965 to correct the pervasive mismanagement of ADPE. It established a centralized system of ADP management within the Executive Branch. OMB was assigned responsibility for policy and fiscal matters. GSA was assigned operational responsibility for ADPE procurement, maintenance and utilization. NBS was assigned the technical aspects of ADP management. Finally, the user agencies retained certain management responsibilities.

An examination of the legislative history of P.L. 89-306 reveals that the centralization concept of the law was based to a significant degree on two technological assumptions. These assumptions were 1) the extensive use of large, centralized computers and timesharing, and 2) ADPE compatibility and standardization. A review of computer history, as presented in Chapter Two of this thesis, indicates these assumptions have not been fulfilled. Instead, low cost small-scale ADPE, such as minicomputers and microcomputers, have become prevalent and the rapid evolution of computer technology has inhabited standardization and compatibility. While current problems in ADP management cannot be blamed solely on these technological miscalculations, these changes in technology have contributed to some of the problems.

IV. ADPE Acquisition and Management Regulations

The acquisition and management of ADPE within the federal government is controlled by a complex hierarchy of regulations. The capstone of this hierarchy is Public Law 89-306 which provides the basic structure and concepts for the government-wide system of ADP management. In the Executive branch this law has been implemented through the promulgation of special rules by the Office of Management and Budget (OMB), the General Services Administration (GSA), and the individual federal agencies. Within this last category, the Department of Defense (DOD) has issued a series of directives, instructions, and manuals, and the Secretary of the Air Force (SAF) has published a series of orders dealing with ADPE. These DOD and SAF rules have been implemented within the Air Force by the 300-series of regulations. Finally, the 300-series regulations have been supplemented by the major commands (MAJCOMs) and, in some cases, individual bases. In addition to these specialized rules, ADPE acquisition and management is also subject to the general rules covering all federal procurement and property management.

This chapter presents an overview of the ADP regulatory structure with emphasis on the Air Force ADP regulations dealing

with acquisition and management. The purpose is to accomplish the third sub-objective of this thesis research: identify the major policies and responsibilities under the present ADP management program for the acquisition and control of ADPE. First, a brief summary is given of the rules issued from the Congressional through the SAF level. Then, the Air Force ADP regulations which cover ADPE acquisition and management are reviewed.

The governmental ADP regulatory system is extraordinarily complex. Recent articles in Datamation and Government Executive magazine speak of the ADP regulations in the following terms: "procurement maze," "Federal Computer Mess," "bewildering blizzard of intertwined, overlayed and potentially conflicting rules," "written in ancient Greek." (Flato, 1978:239; Baynard, 1976:28; The Federal ADP Procurement Maze, 1977:49) It is beyond the scope of this chapter to present a complete and definitive review of these ADP regulations; rather, a summarized and simplified overview of the more pertinent regulations is provided.

Congress--Public Laws Affecting ADPE

Numerous laws enacted by Congress have an impact on ADPE acquisition and management. The most significant of these is P.L. 89-306. Since this law was examined in detail in Chapter Two, only a brief summary is presented here. P.L. 89-306 provides the

basic structure and concepts for the government-wide program of ADP management. It centralized ADP management responsibilities in three agencies within the Executive branch. OMB was assigned responsibility for ADP policy and fiscal matters. GSA was assigned responsibility for ADPE procurement, maintenance, and utilization. NBS was assigned the technical aspects of ADP management. Finally, the user agencies retained certain management responsibilities.

Other public laws are more general and apply to all types of property, including ADPE. For example, the Armed Services Procurement Act of 1947 authorized the DOD to promulgate the Armed Services Procurement Regulations (ASPR). While the regulations implementing P.L. 89-306 are primarily concerned with internal government policies, the ASPR deals primarily with the procurement and contracting relationship between the government and private enterprise. Many other laws affect this procurement relationship. Examples are the Small Business Act, the Defense Production Act (concerning labor surplus areas), the Equal Employment Opportunity Act, and the Contract Work Hours and Safety Standards Act. Still other laws deal with the management and control of government property and data. Examples are the Federal Property and Administrative Services Act, the Privacy Act, and the copyright laws. Thus, P.L. 89-306 and a multitude of other laws affect the acquisition and management of ADPE. (Nash, 1977:38-41, 487-596; The Federal ADP Procurement Maze, 1977:50, 52)

OMB

The Office of Management and Budget has broad policy and fiscal authority within the Executive branch. This authority derives from two sources. First, as a staff office of the President, OMB inherently possesses extensive authority to implement Presidential policy. Secondly, OMB has been assigned specific duties and responsibilities under certain public laws, such as P.L. 89-306.

This policy and fiscal authority is generally implemented through the issuance of OMB circulars. The following quotation summarizes the affect of pertinent OMB circulars on ADP acquisition and management.

> Circular A-71 delineates the organizational responsibilities administering ADP activities. Circular A-44 covers management improvement, including ADP. Circular A-11 tells you how to submit your ADP budget. Circular A-90 covers coordinating ADP information systems with state and local governments. Circular A-76 gives guidance on whether to obtain a computer for in-house operations or obtain commercial ADP services. Circular A-94 specifies how to calculate the cost of money required in evaluating ADP procurements. Circular A-108 gives guidance on complying with the Privacy Act. Circular A-109 prescribes procedures for acquiring major systems. (The Federal ADP Procurement Maze, 1977:50, 52)

GSA

The General Services Administration has broad policy and operational authority over the acquisition and management of

government property and services. While GSA has been delegated certain authority by OMB, other specific duties and responsibilities have been assigned to GSA by laws such as P.L. 89-306. Within GSA, the Automated Data and Telecommunications Service is assigned the primary responsibility for ADPE.

GSA policy and operational control are implemented via the Federal Procurement Regulations (FPR), the Federal Property Management Regulations (FPMR), and Federal Management Circulars (FMC). In June 1978, GSA announced that its regulations and circulars dealing with ADPE would be revised by the end of this year. While the revision effort is just now beginning, the changes being considered indicate a trend toward more autonomy and flexibility for the user agencies. The possibilities under consideration are discussed in Chapter Six, Data Analysis.

Since this revision is in progress, the present GSA regulations are only briefly reviewed here. The FPR is essentially equivalent to ASPR. It governs the procurement and contracting relationship between government agencies, excluding DOD, and private enterprise. The FPMR apply to all government agencies including DOD. This voluminous set of regulations covers the acquisition, management, operation, utilization, and control of ADPE and other government property. Some appreciation for the scope of the FPMR can be gleaned just from the titles of various sections: Procurement and

Contracting; Reutilization of ADP Equipment and Supplies; Management and Control of Computer Rooms and Related Support Areas; Care and Handling of Magnetic Computer Tape. The FMC are issued by GSA to deal with specific issues. An example is FMC 74-5 which specifies the justification required before an agency may initiate an ADPE procurement action. Thus, the FPR, FPMR, and FMC implement the policy and operational authority of GSA. (House Legislative and National Security Subcommittee, 1976:18, 42, 33-35; Flato, 1978:238, 239; FMC 74-5, 1974:B-1)

DOD and SAF

The Department of Defense and the Secretary of the Air Force have issued a series of orders, directives, instructions, and manuals to implement the government-wide OMB and GSA regulations along with internal DOD and AF rules. DOD Directives 5100.40, Responsibilities For The Administration Of The Automatic Data Processing Program, and 4105.55, Selection And Acquisition Of Automatic Data Processing Resources, assigned responsibility for DOD ADP management to the Assistant Secretary of Defense, Comptroller and required the appointment of a senior ADP policy official in each of the military services. Within the Air Force, SAF Order No. 560.1 assigned this duty to the Director of Data Automation, HQ USAF.

The individual DOD and SAF regulations are not discussed further since they are directly implemented by the Air Force 300-series of regulations. Rather, as each pertinent Air Force regulation is discussed below, the corresponding DOD and SAF regulations are listed. (Hoats, 1976:5; HQ USAF/KRA letter)

Air Force 300-Series Regulations

The Air Force ADP management program is implemented through the 300-series of regulations. This body of rules consists of nine regulations and two manuals. The title and numeric designator of each of these are listed in Appendix D. As this list illustrates, the 300-series regulations cover a wide range of ADP issues from acquisition and management to planning, programming languages, security and privacy. These 300-series regulations are also supplemented and supported by numerous other manuals and technical instructions. For example, detailed instructions on maintaining the ADPE inventory are contained in AF Manual 171-403.

Since this thesis focuses on the acquisition and management of ADPE, the review of the 300-series regulations is limited to three pertinent volumes--Air Force Regulation (AFR) 300-2, AFR 300-12, and Air Force Manual (AFM) 300-6. However, the breadth and complexity of even these three documents, which total about 250 pages, prohibit a detailed, comprehensive review. Rather, a summary is

presented of relevant sections of each volume. The objective here is to identify the major requirements and responsibilities for the acquisition and management of ADPE. In Chapter Six, a more detailed examination of appropriate sections and paragraphs is included as needed in the analysis cf particular ADP problems and issues.

<u>AFR 300-2: Management of the USAF Automated Data Processing Program</u>.

> This regulation established the Air Force Automated Data Processing (ADP) Program and prescribes policies and responsibilities for managing automated data processing systems, capabilities, services, and associated ADP resources. It applies to all Air Force activities with responsibilities for planning, authorizing, designing, developing, selecting, acquiring, using, maintaining, or managing automated data processing systems (ADPS), or elements thereof. It implements DOD Directives 4105.55, 19 May 1972; 4105.65, 29 June 1970; 4160.19, 5 April 1973; 5100.40, 19 August 1975; DOD Instructions 4120.17, 29 December 1972; 5010.27, 9 November 1971; 5030.40, 27 March 1969; and DOD Manual 4120.17-M. (AFR 300-2, 1977:i)

AFR 300-2 is divided into two sections. Section A is entitled "Policy" and Section B is entitled "Responsibilities." Each section is now briefly summarized.

Section A, Policy, explains the terminology, scope, objectives, and general policies of the AF ADP program. First, the regulation defines nineteen ADP-related terms. Six of these--USAF ADP

Program, Managers, ADP Personnel, ADPE, ADP, and ADPS--are reproduced in Appendix A of this thesis. Next, in Section A, the scope of the ADP program is discussed. Paragraph 2.a.(1) states:

> Selective ADP management policies are to be applied, both to systems that are predominantly ADP-oriented and to ADP resources and capabilities employed as dedicated elements, subsystems, or components of more extensive systems.

Paragraph 2.a. goes on to discuss the relationship between the 300-series regulations and eleven other AF acquisition and management regulations. As an example, paragraph 2.a.(4) states:

> AFR 4-2 establishes policy for the acquisition and management of administrative systems. ADP capabilities required in support of such administrative systems will be developed, acquired, and managed in accordance with this regulation [AFR 300-2].

The objective of the ADP program is briefly stated in paragraph 2.b. as follows:

> The primary objective of the Air Force ADP program is to provide responsive support to critical and vital elements of combat forces. The secondary objective is to support conservation of resources.

Section A then explains the general management policies applicable to ADP acquisition, requirement documentation, design and development, selection/acquisition, implementation, operation, reutilization, and sharing. The policies with which this thesis is concerned--ADPE acquisition and ADPE management--are reiterated

in AFR 300-12 and AFM 300-6, respectively. To avoid redundancy, the AFR 300-2 discussion of these issues is not analyzed.

Section B of AFR 300-2, entitled "Responsibilities," assigns particular management authority and responsibility to HQ USAF and the MAJCOMs. The Director of Data Automation, HQ USAF, is designated as the Air Force ADP program single manager (the various classifications of ADP managers are defined under "Manager" in AFR 300-2 and in Appendix A of this thesis). The AF single manager and his or her associated HQ USAF staff offices are assigned twenty-nine specific responsibilities. Included among these are 1) ensuring that adequate plans, policies, programs, and directives exist or are generated to govern the selection, acquisition, and utilization of ADP resources; 2) managing AF participation in the government-wide ADP sharing and ADPE reutilization programs; 3) appointing USAF ADPS managers and functional ADS managers. AFR 300-2, Section B, also requires each MAJCOM to designate a command ADP program single manager. This single manager is assigned twelve specific responsibilities. These range from "Provide ADP support for the command mission" to "Provide for an ADP equipment inventory." AFR 300-2 also assigns certain responsibilities to the USAF and Command ADPS managers, and the functional ADS managers.

Among the most important authority granted under Section B of

AFR 300-2 is the authority to approve the acquisition of ADPE. This approval authority is restricted to designated ADP managers as defined in Appendix A. Additionally, the approval authority for each level of ADP management is limited to a particular dollar-value threshold for each type of procurement action. These approval authority thresholds are summarized in Appendix E.

In summary, AFR 300-2 establishes the AF ADP program and prescribes policies and responsibilities for managing ADP resources. Section A, Policy, defines ADP-related terminology, specifies the scope and objectives of the ADP program, and establishes general policy for ADP management. Section B, Responsibilities, assigns specific authority and responsibilities to the various classifications of ADP managers. Of particular significance, it establishes ADP acquisition approval thresholds for each level of ADP management.

<u>AFR 300-12: Procedures for Managing Automated Data Processing Systems--Documentation, Development, Acquisition, and Implementation.</u>

> This volume establishes the procedures for documentation, development, acquisition and implementation of Air Force ADPS or ADPS elements. It implements DOD Directives 4100.5, July 8, 1971; 4105.55, May 19, 1972; 4105.62, January 6, 1976; and DOD Instructions 4100.33, July 16, 1971; 4105.65, June 29, 1970; 5010.27, November 9, 1971; and DOD Manual 4120.17-M (AFR 300-12, 1977:i)

AFR 300-12 Procedures--Overview. AFR 300-12 specifies the procedures an AF organization must follow in acquiring and implementing ADPE. Initially, the organization must prepare a Data Automation Requirement (DAR). This document describes the requirement for ADPE and provides the necessary data for justifying that ADPE is the most effective means to satisfy that requirement. The DAR is then evaluated by the appropriate ADP approval authority as specified in AFR 300-2. If the approving authority determines that acquisition of ADPE is the most feasible means to satisfy the requirement, approval is granted through a Data Project Directive (DPD). This document grants approval, authorizes expenditures, and assigns responsibilities for the acquisition. Next, the ADP project manager, as specified in the DPD, prepares a Data Project Plan (DPP). This document represents the principal management and control tool to be used throughout the project. Finally, during the actual procurement and implementation of the ADPE, a series of management reviews and milestone reports must be accomplished.

Having overviewed the AFR 300-12 procedures, each of the three major documents mentioned is now individually discussed. The emphasis is on the DAR since it is the basic means through which an ADPE acquisition is initiated and evaluated. The AFR 300-12 instructions for preparing the DAR, DPD, and DPP are reproduced in Appendix F. The management reviews and milestone reports

mentioned above are not discussed since they vary extensively with the scope and complexity of a project.

<u>Data Automation Requirement (DAR)</u>.

> The DAR describes a requirement for ADP resources and provides the basis for concluding that ADP resources are either essential or the most effective means to satisfy the requirement. (AFR 300-12, 1977:2-2)

Since the AFR 300-12 instructions on preparing a DAR, reproduced in Appendix F, specify the contents of the document, this discussion will focus on when a DAR is needed and how a DAR is evaluated. The question of when a DAR must be prepared is answered by paragraph 2-5 of AFR 300-12.

> Requirements for developing, modifying, or maintaining an ADPS, or an ADS, or for acquiring ADPS components, will be documented using the DAR format. (AFR 300-12, 1977:2-2)

Thus, the acquisition of any item of ADPE, regardless of use, size, capability, or price, requires submission, evaluation, and approval of a DAR. However, the amount of detail provided in the DAR is permitted to vary.

> The level of detail provided in the DAR will be commensurate with the scope of the requirement and resources to be committed. (AFR 300-12, 1977:2-2)

AFR 300-12, paragraph 2-5e, in conjunction with AFR 300-2, paragraph 4f, specify how a DAR is to be evaluated. Each of these is

presented below.

> DARs are evaluated on mission essentiality, feasibility of the proposed solution and requirement satisfaction. Also see AFR 300-2, paragraph 4f. (AFR 300-12, 1977:2-3)
>
> f. The use of ADP resources to meet validated requirements will be approved only when the documentation shows that:
>
> (1) The lowest overall cost alternative at an acceptable level of technical risk is determined prior to the selection and acquisition of ADP resources, and
>
> (2) Funds have been budgeted and programmed properly. (The commitment of funds will not exceed the approved budget, any ceiling or target, nor any Congressional limitations.), and
>
> (3) A valid information requirement exists, as determined under AFR 178-7, when AFR 178-7 is applicable, and
>
> (4) The tangible benefits offset the cost of ADP resources, or
>
> (5) Improved performance, even though the improvement may never be tracable to auditable savings, providing the improved performance is described and there is confidence that the proposed automation will achieve all or most of the desired benefits. Even though these benefits are intangible, it is possible to assign a dollar value to them. (For example, the Air Force spends money every year to improve "quality of life"; there is an explicit quantification of value when it is decided to spend a sum of money to remodel a dormitory or a dining hall, even though it is not possible to track directly to improved retention) or
>
> (6) The cost and value are presently uncertain and use of prototype development can be used as a vehicle to derive definitive costs and definitive benefits (tangible or intangible). Justification for prototyping should indicate that strong suspicion exists that benefits will out-weigh costs. (AFR 300-2, 1977:4)

The appropriate ADP approval authority, as designated in AFR 300-2, uses the above criteria to evaluate a DAR. If the DAR is approved, the ADP staff at the DAR approval level prepares a DPD.

Data Projective Directive (DPD).

> The DPD grants approval, directs specific actions, designates participants, assigns responsibilities, authorizes resource expenditures, defines project scope, and documents key decisions . . . . The DPD is the primary management control document for an ADP program/project. (AFR 300-12, 1977:2-3)

The AFR 300-12 requirements for DPD format and content are reproduced in Appendix F. Similar to a DAR, "The scope of the DPD must be commensurate with the level of the approval requirement and the resources to be allocated." (AFR 300-12, 1977:2-3)

Data Project Plan (DPP).

> The DPP describes actions to be taken to achieve project performance, schedule, and costs objectives specified in the DPD . . . . It will provide for performance measurement and evaluation at specified milestones. The DPP represents the principal management and control tool to be used throughout the project and, when completed, constitutes documentation of the actions to be taken to accomplish the project. (AFR 300-12, 1977:2-4)

The detailed instructions for preparing a DPP are reproduced in Appendix F. As with the DAR and DPD, "The DPP will be prepared at a level of detail commensurate with the scope, costs, and

complexity of the project." (AFR 300-12, 1977:2-4) The ADP project manager, who is designated in the DPP, is responsible for preparing the DPP and obtaining its approval by the ADP single manager who issued the DPD.

AFM 300-6: Automatic Data Processing (ADP) Resource Management.

> This manual contains guidance and established requirements for the operation and management of Automatic Data Processing Resources (ADPR) and Automatic Data Processing Equipment (ADPE) in the operational phase. It supports and advances the objectives and policies prescribed in the 300 series Air Force Regulations. It applies Air Force activities using or planning to use ADPR . . . . This manual implements DOD Directives 4160.19, DOD Manual 4160.19-M, and Federal Management Circular 74-2. (AFM 300-6, 1975:i)

AFM 300-6 covers the broad categories of ADPE operation and management. As a result, it probably has the widest scope of any of the 300-series volumes. The following examples from the table of contents illustrate its wide applicability: "Release of Information to the Public," "ADP Security," "Programming and Budgeting for the Air Force Data Systems Automation Program," "ADP Organization, Manpower, and Personnel," "Guidance for ADP Contractual Matters," "Care and Handling of Disk Packs," "ADP Supplies," and "ADPE Inventory." This discussion of AFM 300-6 is limited to two topics--the ADP Sharing Program and the ADPE Inventory. Other aspects of

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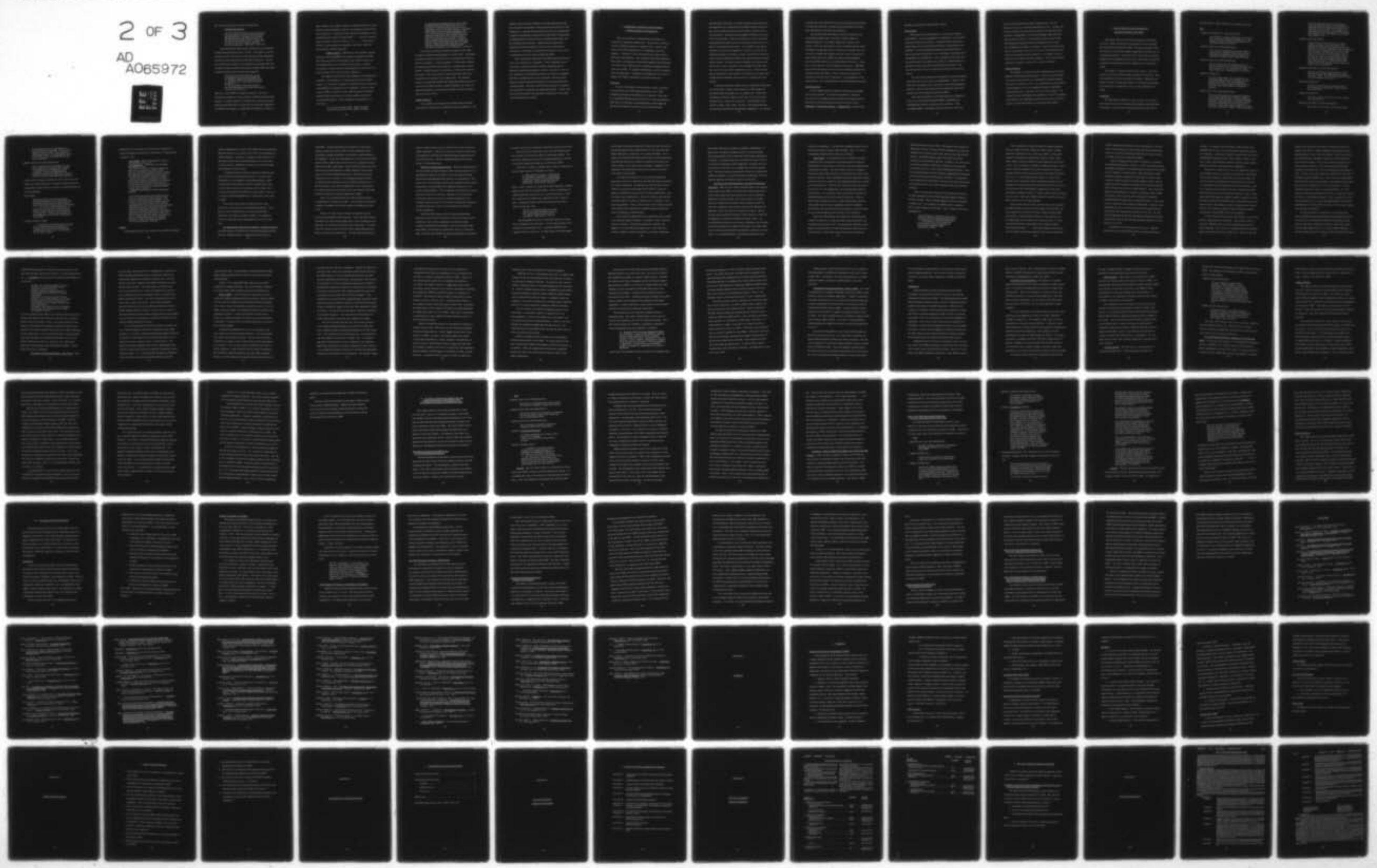

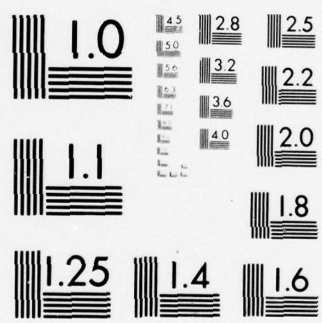

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the manual are presented as needed in Chapter Six.

> <u>ADP Sharing Program</u>.
>
> Air Force activities and Air Force contractors will participate in the Government-Wide ADP Sharing Program. Managers will maximize the efficient utilization of ADP resources by sharing the use of such resources among other Air Force and DOD activities, and other government agencies. (AFM 300-6, 1975:11-1)

A government-wide ADP sharing program has been established by GSA under the auspices of P.L. 89-306. This program is part of the effort to move away from an agency-by-agency ADP management structure and toward government-wide ADP management. The purpose of this sharing program is to minimize governmental ADP costs through the maximum efficient utilization of existing ADPE regardless of which government agency possess the equipment.

> The importance of this [sharing] concept is illustrated by the fact that justification for additional ADPE must substantiate that:
> a. Maximum use is being made of existing equipment . . . .
> b. The possibility of sharing computers has been examined and was found not practical.
> (AFM 300-6, 1975:11-1)

However, certain ADPE is exempt from sharing. AFR 300-2 specifically exempts four broad categories of ADPE from the sharing program: 1) analog computers, 2) ADPE built to special government design specifications which is usable only for the specific application for which it was designed, 3) ADPE which is integral to a weapon or

space systems, and 4) ADPE serving as a dedicated element of a more extensive system developed, acquired, and managed by non-AFR 300 series directives. In addition to these categorical exemptions, an AF organization may request to exempt ADPE " . . . because of reasons such as security, economy, efficiency, etc. . . . . " (AFM 300-6, 1975:11-2) Such requests are submitted to HQ USAF, which then forwards them to GSA for approval.

ADPE Inventory. AFM 300-6 provides guidance and procedures for the accountability and inventory management of ADPE. This discussion focuses on the purpose of the ADPE inventory and the equipment that is to be included in the inventory. Detailed instructions on implementing and maintaining this inventory are contained in AFM 171-403 and AFM 300-6, Chapter 11.

The ADPE inventory has two main purposes--accountability and visibility. Accountability is a common purpose for any inventory system. It is desirable to maintain a documented chain of control and responsibility for identifiable items of equipment. However, some items of ADPE are contained on the ADPE inventory for visibility purposes only; these items are carried on another inventory for accountability purposes. This is explained by paragraph 13-4 of AFM 300-6.

> 13-4. Nonaccountable ADPE. While the ADPE inventories prescribed by this chapter constitute

> an equipment accountability system, some ADPE contained within the mechanized inventory are reported for visibility purposes only and are not accountable as part of the ADP Program. Reportable ADPE which are nonaccountable through the Air Force ADP Program are those ADPE which were acquired outside of the ADP Program (defined in AFR 300-2) and which are currently carried in another equipment inventory system. Examples may include AUTODIN terminals acquired through DECCO, ADPE within flight simulators, inventoriable government furnished equipment (GFE) provided to contractors, etc. (AFM 300-6, 1975:13-2)

The question of what items should be included on the ADPE inventory is addressed by paragraph 13-2 of AFM 300-6. Essentially, all ADPE as defined in AFR 300-2 is to be included in the inventory with four exceptions: 1) analog computers, 2) ADPE built to special government specifications and integral to a combat weapon or space system, 3) ADPE procured by contractors or GFE provided contractors under a cost reimbursement contract (GFE under other type contracts are not exempt), and 4) supply items. The following factors are specifically excluded from influencing whether an item is carried on the ADPE inventory: method of funding, use, source of approval/acquisition, and interfacing with other systems internal or external to the Air Force.

Chapter Summary

The acquisition and management of ADPE within the federal government is controlled by a complex hierarchy of regulations. The

capstone of this hierarchy is Public Law 89-306 which provides the basic structure and concepts for the government-wide system of ADP management. In the Executive branch this law has been implemented through the promulgation of special rules by the Office of Management and Budget (OMB), the General Services Administration (GSA), and the individual federal agencies. Within this last category, the Department of Defense (DOD) has issued a series of directives, instructions, and manuals, and the Secretary of the Air Force (SAF) has published a series of orders dealing with ADPE.

These DOD and SAF rules have been implemented within the Air Force by the 300-series of regulations. These regulations cover a wide range of ADP issues from acquisition and management to planning, programming languages, security, and privacy. Three of the regulations are particularly pertinent to this thesis investigation. AFR 300-2 establishes the Air Force Automatic Data Processing Program and prescribes the broad policies and responsibilities for managing ADPE. AFR 300-12 specifies the procedures on organization must follow in acquiring and implementing ADPE. Finally, AFM 300-6 provides guidance and establishes requirements for the operation and management of ADPE.

V. Methodology for Analyzing Current Problems in ADPE Acquisition and Management

This research effort is organized into six specific sub-objectives as specified in Chapter One. The first three of these--a review of computer progress, an analysis of P.L. 89-306, and a review of the ADP regulations--are accomplished in previous chapters. A literature review and analysis were used to achieve these three sub-objectives. The remainder of this thesis addresses the last three sub-objectives and tests the hypothesis that technological advances have rendered present ADP policies inappropriate for small-scale ADPE. An expanded methodology is used to accomplish these remaining tasks. Although this methodology is overviewed in Chapter One, further elaboration is presented at this time.

Interviews

The goal of identifying current problems, issues, and effects involving small-scale ADPE suggested that the views of ADP management personnel and ADPE users be examined. This could be accomplished through either interviews or a survey questionnaire. While there are advantages and disadvantages to either approach, the interview method was selected because it allowed verbal

communication between the researcher and those being interviewed. This opportunity for communication was highly desirable because of the variety of people interviewed and the unique, subjective nature of the questions. Both personal and telephone interviews were used in the research effort. Before each interview a series of questions was prepared to provide structure to the interview and to serve as a guide in collecting the desired data. As an example, some typical questions are presented in Appendix B. However, in all cases, the prepared questions served only as a guide. Questions were added or deleted as the knowledge and insights of the person being interviewed became evident. The initial interview questions were based on this writer's four years of experience in the computer field and a literature review of current ADP management issues. As the interview process progressed, some questions were added as new issues came to light and some questions which proved to be of little value were deleted.

A total of twenty-three people from four MAJCOMs and HQ USAF were interviewed. Sixteen of these people are ADP management personnel and the remaining seven are ADPE users. Of the ADP management personnel, eight are at the base level, six are at the MAJCOM level, and two are at HQ USAF. The MAJCOMs represented are AFSC, AFLC, MAC, and ATC. This information about the personnel interviewed is summarized in Appendix C. As stressed

in Chapter One, the individuals interviewed were promised anonymity. To insure this anonymity, assignment and organizational data about these individuals is not further sub-classified.

The selection of the individuals to interview could have been accomplished through either a scientific, random method or a subjective approach. The random method was rejected for two reasons. First, the interviews were time-consuming and this limited the number of people that could be interviewed. Secondly, there was no means to identify ADP managers and users who were particularly involved with small-scale ADPE; the random method might have selected individuals who were not knowledgeable in this area. Therefore, a more subjective selection approach was chosen. Individuals were selected who appeared to have special knowledge and experience involving small-scale ADPE. Actual selections were based on a literature search, the writer's experience, recommendations of the thesis advisor, and recommendations of initial individuals interviewed.

Literature Search

It was recognized that the subjective selection process might bias the data collected. To alleviate this problem, a literature search was used to supplement the data gathered through interviews. Information on ADP management was found in sources such as Datamation, Government Executive, Computerworld, Congressional

hearings, and General Accounting Office reports.

Data Analysis

The analysis of the data gathered is, of necessity, subjective and qualitative. As each sub-objective is addressed, a cross-section of the data collected is presented. In keeping with the stated policy of this thesis, the interview data presented are not attributed to any individual. The only identification attached to individual datum is that it represents the opinion of a base, MAJCOM, or HQ USAF ADP administrator or an ADPE user. Also, it should be made clear that the interview data is not quoted, but, rather is a summarization of a discussion between this writer and the person interviewed. Data from the literature search are quoted and referenced in the normal manner.

This data is then synthesized and analyzed to reach some logical conclusions and, in some cases, recommendations. However, this writer does not purport to have solved the current ADP management problems. Many of these issues have been debated by expert ADP managers for years without successful resolution.

Also, this data analysis is performed under two assumptions. First, it is assumed that widespread ADPE compatibility and standardization will not be achieved in the near future. This assumption appears reasonable based on two factors. First, the

governmental standardization effort, initiated by P.L. 89-306 thirteen years ago, has achieved only limited success. Secondly, the technical computer literature does not indicate any impending breakthroughs in compatibility. The second assumption under which this data is analyzed is that P.L. 89-306 and the basic structure of the ADP management program will not be changed in the near future. This assumption also appears reasonable. Congressman Brooks, the sponsor and principal backer of P.L. 89-306, is now chairman of the House Government Operations Committee. Any changes to the law would have to be approved by this committee. The current literature indicates that change or repeal of P.L. 89-306 is unlikely.

Chapter Summary

This chapter is a discussion of the methodology used to accomplish the remaining tasks of this thesis. Three of the six sub-objectives of this research effort are accomplished in previous chapters by means of a literature review. The remaining three sub-objectives and the hypothesis test are accomplished through a methodology involving interviews, a literature search, and data analysis. The rationale for this methodology, the preparation of interview questions, a description of the individuals interviewed, the interview selection process, and the data analysis are described in this chapter.

VI. Current Problems in the Acquisition and Management of Small-Scale ADPE

This chapter addresses the fourth sub-objective of the thesis research: identify and examine current problems in the acquisition and management of small-scale ADPE. The primary purpose of this sub-objective is to determine whether inappropriate ADP policies are causing these problems. This represents a major step in testing the hypothesis that technological advances have rendered the current ADP acquisition and management policies inappropriate for small-scale ADPE.

This chapter is organized into two main sections. First, the problems and issues involving ADPE acquisition are discussed. Then, the management of small-scale ADPE is examined. While this sub-objective focuses on small-scale ADPE, it is inevitable that portions of the discussion are applicable to all sizes and classifications of ADPE.

Acquisition

The acquisition of ADPE was a topic of major concern both in the literature surveyed and among the ADP managers and ADPE users interviewed. A cross-section of the data collected on this issue is

presented below. This is followed by an analysis of the data.

Data

--Opinion of MAJCOM level ADP administrator:

> The authority to approve acquisition of a minicomputer remains at a high bureaucratic level. This approval requires extensive justification and an inordinate amount of lead time.

--Opinion of base level ADP administrator:

> The volume of acquisitions exceeds the capacity of the system resulting in delays and problems. DAR approval authority and GSA Delegation of Procurement Authority limits should be raised.

--Opinion of base level ADP administrator:

> The time delays in the DAR-funding cycle are costly, especially if you consider opportunity costs. There needs to be a new procedure for small dollar value items. Something like a mini-DAR.

--Opinion of ADPE user:

> For some small dollar value acquisitions, the acquisition approval process probably cost more than the item itself. This would especially hold true if you consider the savings lost by not having the item while waiting for acquisition approval.

--Opinion of base level ADP administrator:

> The crux of the matter is the amount of authority and the dollar approval limits that are delegated to the local single manager. In dealing with small computers, especially those used in the scientific area, the local manager needs a great deal of flexibility. Many of the small computers are used as part of much larger systems. The local manager

needs the authority to be able to expedite the acquisition approval of these small computers in order that they flow with the procurement of the system they are a part of. For example, it is not logical to delay a multi-million dollar project while waiting for Air Staff approval of a $51,000 minicomputer lease.

--Opinion of HQ USAF official:

People tend to overstate the large vs. small computer problem. The basic policies that apply to the acquisition and management of large computers are just as applicable to small computers--only the scope or depth of the procedures should vary. However, the acquisition process for all ADPE can be improved. For example, many of the steps we now do sequentially could be done concurrently (such as benchmarking and negotiation with contractors). Another improvement would be to develop standard contract clauses for various types of acquisitions.

--Opinion of MAJCOM level ADP administrator:

The DAR is basically a good document. Users should have to provide justification and analysis to acquire ADPE. The ADP management personnel can be of assistance to the user.

--Opinion of ADPE user:

The DAR is useful in that it forces the user to do the analysis and planning he might otherwise have failed to do.

--Opinion of ADPE user:

The DAR is useful in that it forces you to analyze your requirements.

--Opinion of MAJCOM level ADP administrator:

Some ADP users feel they cannot know and plan

> their requirements far enough ahead to go through the 300-reg channels. However, they should be able to do this. This is partly an educational problem. Some people have never done a DAR or been associated with the 300-series procedures.

--Opinion of base level ADP administrator:

> Some of the people at the Pentagon are still locked into the old concepts of the computer as something to aid in doing payroll and accounting. They do not understand that additional authority and flexibility is needed at the local level in dealing with small computers.

--Numerous ADP management personnel at all levels and several ADPE users indicated they have encountered problems in determining whether items should be classified as ADPE under the 300-series regulations.

--GAO report:

> Agency personnel told us that intolerable procurement delays were resulting from their own internal documentation requirements as well as from GSA's documentation requirements . . . . In a survey of 149 installations, 39 percent say they experienced unreasonable delays in acquiring and/or implementing the minicomputers. (Report to the Congress by the Comptroller General of the United States, 1977:19-20)

--Brooks Committee report:

> . . . immediate cost benefits and time savings can be realized through the institution of simplified procedures for procurement of smaller dollar value items. (House Report No. 94-1746, 1976:12)

--Statement by Vico Henriques, Vice President, Computer and Business Equipment Manufacturers Association, to Congressional committee, 1976:

> Mr. Brooks. What are the primary causes of the long procurement cycle?
>
> Mr. Henriques. I think there are two things that impinge on that.
>
> One is the necessity for multilevel approvals, both in the user agency and in the central agencies--stretching from the end user, who has the authority and responsibility for the mission, throughout the complex procurement system.
>
> Second is the lack of a stratified or modular procurement system as outlined in our testimony. The majority of the procurements are forced into the same mode with the result that there are so many procurement actions going through the system it gets clogged up.
>
> [Additional information provided subsequently follows:]
>
> One of the major factors preventing the realization of cost-effective ADP operations is the long and complex procurement system. In the testimony we recommended a flexible approach to procurements that recognizes the cost and complexity of the system to be procured and would differentiate between acquisition of ADP for: totally new applications, workload increases, extensions to existing applications, and technical improvements to do the same job at lower cost. Such a stratified approach should streamline the process and alieviate many of the attendant problems. (House Legislative and National Security Subcommittee, 1976:198)

Analysis

If technological advances have rendered current ADP acquisition

policies inappropriate for small-scale ADPE, then one would expect that these policies are a primary cause of the current problems in ADPE acquisition. Therefore, one purpose of this analysis is to determine whether these acquisition policies are a cause of the current problems. Additionally, the data can be used to identify other problems and their causes.

A significant amount of the data collected consisted of complaints about the ADPE acquisition process. Of course, these complaints are only symptoms of underlying problems. While the individuals interviewed often discuss complaints and issues in terms of their particular environment, three common areas of concern with small-scale ADPE do become evident. These are 1) excessive justification/paperwork, 2) time delays, and 3) what is ADPE?

This analysis first examines whether the basic ADP policies are a cause of the current acquisition problems. Then, the three issues identified above--excessive justification/paperwork, time delays, and what is ADPE-- are considered and some conclusions and recommendations are made for each topic.

Are Inappropriate ADP Policies Causing Acquisition Problems? The ADP managers and ADPE users interviewed generally felt that the basic acquisition policies as implemented by the DAR are

worthwhile. Included among these basic policies are the requirements to analyze the need for ADPE, provide justification for the acquisition, evaluate alternatives, and to plan for implementation of the equipment. As the above data indicates, several users commented that the DAR is useful in that it forces the user to adequately analyze and plan his ADPE requirements. Also, the ADP managers and users interviewed generally approved of ADPE acquisitions coming under the purview of ADP management personnel, rather than being left entirely to the users' control. Two frequently mentioned benefits accruing from this specialized review of ADPE acquisitions were 1) that the expertise of the ADP staff helped the users in selecting the best ADPE alternative to meet their needs, and 2) that the ADP staff personnel could prevent needless duplication of ADPE.

Thus, it is concluded that the basic ADP acquisition policies are appropriate for small-scale ADPE. These policies are generally accepted as worthwhile by the ADP managers and ADPE users interviewed.

However, the data seems to indicate two primary concerns about the implementation of these policies. First, both ADP managers and ADPE users expressed the opinion that excessive justification and paperwork are required for low dollar value acquisitions. Yet, these comments seemed to focus on the procedures implementing the basic policies, not the policies themselves. Secondly, both ADP managers

and users expressed deep concern about the time delays involved in ADPE acquisitions. In this case, the concern seemed to focus on the centralization of ADP approval authority at high management levels. Each of these issues--excessive justification/paperwork and time delays--are discussed below.

Excessive Justification/Paperwork. While the individuals interviewed generally considered the basic ADP acquisition policies to be appropriate for small-scale ADPE, concern was expressed about the procedures through which these policies are implemented. This concern was evinced through comments and complaints about excessive justification, excessive paperwork, duplicative paperwork, over-control, and inflexibility. These complaints also relate to the concern about time delays since excessive, duplicative work wastes time. Two specific aspects of excessive justification/paperwork were mentioned in the interviews--1) the amount of justification, paperwork and detail required in a DAR, and 2) the duplication of DARs for similar acquisitions.

Numerous ADP managers felt the amount of justification, paperwork, effort and time required for a DAR is not commensurate with the low costs of some acquisitions--the breakeven point frequently mentioned was about \$2000. Even at costs significantly above \$2000, some managers questioned the value of a "full-blown" DAR. Basically, they felt that the minimum justification and analysis

necessary for low cost acquisitions required too much time and effort.

This issue of how much detail, time, and effort should be put into a DAR for low cost items reflects an underlying problem. The 300-series regulations have not been adequately adjusted or clarified to reflect the rapidly decreasing cost of small-scale ADPE.

AFR 300-12, Volume I, specifies when a DAR is needed and the level of detail required. Paragraph 2-5a states:

> a. When DARs Are Needed. Requirements for developing, modifying, or maintaining an ADPS or an ADS, or for acquiring ADPS components, will be documented using the DAR format. (AFR 300-12, 1977:2-2)

Thus, a DAR is required for acquiring an ADPS component. ADPS is defined in AFR 300-2 as including ADPE. In turn, the definition of ADPE specifically excludes price as a classification factor. Thus, the acquisition of any ADPE item, regardless of cost, requires a DAR. Paragraph 2-5d(5) of AFR 300-12 addresses the level of detail necessary in a DAR.

> The level of detail provided in the DAR will be commensurate with the scope of the requirement and resources to be committed. (AFR 300-12, 1977:2-2)

This paragraph seems to be very general and leaves a great deal of flexibility to the DAR writer. Yet, the ADP managers seem hesitant to take advantage of this. A possible explanation was suggested during an interview. An ADP manager stated that people

have become nervous about what they do under the ADP bureaucracy. He said that people often box themselves in by worrying about what higher authorities, an inspector, or an auditor will think. Nevertheless, the interview data indicates that numerous ADP management personnel feel that they are required to expend too much time and effort on DARs for low dollar value acquisitions. Suggestions for a shortened, less detailed DAR involved terms such as mini-DAR, letter-DAR, and form-DAR.

A second issue within the area of excessive justification/ paperwork involves the requirement that individual DARs be prepared for similar acquisitions. Specifically, two ADP managers and one ADPE user questioned why multiple DARs should be required to approve acquisitions of similar items for similar applications, often for similar user organizations. They felt it would be more efficient and just as effective to allow one DAR to cover or "blanket" a category of acquisitions. Then, a user who met certain criteria specified in the blanket DAR could have his acquisition approved without the effort of preparing an individual DAR.

The benefits of a blanket DAR can be illustrated using a simple case involving computer terminals. Presently, if a user desires to acquire a terminal, a DAR must be prepared, evaluated, and approved. If a few weeks later another user, or the same user, wishes to acquire an identical terminal for an identical application,

then another DAR must be prepared, evaluated, and approved. It would seem very logical to prepare one DAR covering terminals which would specify various criteria that would justify acquisition of a terminal. A user then need only certify that one of these criteria is met and the acquisition would be approved. Currently, there are no provisions in the 300-series regulations for any type of blanket DAR. While determining the appropriate criteria for a blanket DAR might prove difficult, even for fairly simple acquisitions, the idea is logically appealing and should be tested on a trial basis.

Conclusions and Recommendations: Excessive Justification/ Paperwork. While the basic ADPE acquisition policies are appropriate for small-scale ADPE, the interview data indicate that the procedures which implement these policies have not been adequately adjusted to meet the declining cost and increasing use of ADPE. Numerous complaints about ADPE acquisition approval under the 300-series regulations concerned the amount and the duplication of paperwork, effort, and time for low dollar value items. The two primary issues involved the amount of detail required in a DAR and the duplication of DARs for acquisition of similar items. It is concluded that the primary cause of these complaints is the declining price and increasing use of ADPE and the failure of the ADP regulations to clearly specify the DAR documentation required for low cost items. It is recommended that a mini-DAR be permitted for low

dollar value acquisitions. The 300-series regulations should clearly specify the required contents of this document. Also, it is recommended that a blanket DAR be tested on a trial basis.

Time Delays. A second problem area in small-scale ADPE acquisition is the centralization of acquisition approval authority. This problem is represented in the interview data by complaints about acquisition time delays. The most common and fervent complaint about small-scale ADPE acquisition concerned the time delays or the lead time required. These complaints involved the approvals required under the 300-series regulations, the budgeting/funding cycle, and the procurement process. While the time required for the total acquisition process can vary significantly, the period typically mentioned was two years. It is beyond the scope of this thesis to examine the budgeting/funding cycle and the procurement process. However, based on the comments received, a study of both of these and their relationship to the 300-series regulations would be worthwhile. Nevertheless, this discussion will focus primarily on the time delays due to acquisition approval under the 300-series regulations.

Most of the ADP managers and ADPE users felt that the time required for approval of a Data Automation Requirement (DAR) was inordinately long in many cases. Not surprisingly, DARs that require approval at the HQ USAF level take the longest time and receive the most criticism. These DARs must go from the base through the

MAJCOM and then to the Air Staff. The length of time required for this process varies, of course, with the complexity of the DAR, the workload at the various review levels, and numerous other factors. However, individuals typically spoke of HQ USAF level DARs requiring several months for approval. Needless to say, the process can become extremely lengthy when a DAR has to be returned for correction of an error or more detailed justification/analysis. Several base and MAJCOM level ADP managers emphasized the elaboration and scrutiny they put into DARs going to HQ USAF. For DARs that can be approved at the MAJCOM or base level, the time delay generally decreased and there were fewer complaints from users and ADP managers.

There were numerous references by personnel interviewed to the high management levels at which acquisition approval authority has been retained. These acquisition approval levels are described in Chapter Four. For example, any ADPE purchase, outside of AFSC, requires approval of HQ USAF. Also, as stated in AFR 300-2, paragraph 6(c):

> In most instances, ADP procurement action cannot be initiated without prior approval of the General Services Administration (GSA). . . . The GSA may elect to conduct the procurement or issue a Delegation of Procurement Authority (DPA). (AFR 300-2, 1977:6)

This centralization of approval authority at high management levels is complicated by the rapidly increasing volume of ADPE, especially relatively low cost, small-scale ADPE. Several ADP managers mentioned the resulting large volume of DARs, DPAs, DPDs, DPPs, and other acquisition documentation that must be processed. The increasing use of ADPE is readily documented. At one large AF base the individual interviewed stated that the number of computer systems on their inventory had increased 125% in the past four years. In a 1976 Congressional hearing, Dr. Davis of the National Bureau of Standards (NBS) stated that the number of minicomputers in the federal inventory had grown by 22% each year since 1965 and that by 1975 minicomputers comprised over half of the government's computer inventory. Further evidence of the increasing use of low cost, small-scale ADPE is that 56% of the DPAs issued by GSA in 1975 were for less than $250,000.

Based on this data, the writer concludes that a major problem in ADPE acquisitions is that acquisition approval authority has not been adequately decentralized to handle a rapidly changing ADPE environment. If decentralization would be an improvement, then one might expect to find evidence of a trend toward this. In a 1976 Congressional hearing, the president of the Computer Industry Association stated that, ". . . The Federal ADP procurement process has drifted toward decentralization rather than centralization."

(House Legislative and National Security Subcommittee, 1976:209) Also, in June of this year, GSA announced that its DPA thresholds would be increased from $50,000 to $300,000, the amount varying according to the type of acquisition method.

Systems Command (AFSC) offers an example of a relatively decentralized DAR approval structure. In 1976, HQ AFSC delegated ADP approval authority to the ADPS managers located at twelve major centers, divisions, and laboratories. This allowed these locally designated managers to approve all DARs that are unique to their respective ADPS and within the Command approval limits, with the exception of DARs requiring a Delegation of Procurement Authority (DPA) from the General Services Administration. This included the approval of ADPE purchases, which is an authority unique to AFSC. The managers and users where this local approval authority is available indicated a high degree of satisfaction with it. In fact, they seem to consider this local authority indispensable. However, these individuals also were in consenses that the present approval thresholds and the DPA requirement threshold were too low. The most common suggestion was that the DAR approval authority and the DPA requirement be increased to $250,000 (this figure appeared in House Report No. 94-1746).

A limitation on decentralization must be noted. Computer systems that can be standardized should be centrally acquired and

managed. An example is the Burroughs computer system used throughout the Air Force for such functions as personnel, payroll, and accounting. It would not be logical to suggest that each AF base independently develop and acquire such a system. Rather, as was done in AFSC, decentralization should be limited to unique ADPSs (defined in AFR 300-2 and reproduced in Appendix A).

Furthermore, within the Air Force, the appropriate degree of decentralization will vary according to the particular requirements of each major command. AFSC utilizes the greatest volume and variety of small-scale ADPE among the MAJCOMs surveyed and correspondingly needs the highest degree of decentralization. However, responses from personnel in the other commands generally indicated a desire for increased approval authority. Also, it seems logical that limited approval authority should be delegated to organizational levels below the MAJCOM such as numbered air forces and logistic centers. Essentially, it seems reasonable that the organizational level at which an acquisition must be approved should be commensurate with the dollar value of the acquisition.

The data collected in this research also indicate a second major problem causing delays in acquisitions. This problem is lack of training or education about 1) the ADP acquisition process and 2) ADPE technology. The concern over knowledge about the acquisition process primarily focused on the ADPE users. However, the ADP

managers interviewed were specially selected because they were experts in the field. A random sampling of ADP managers would probably indicate a lower level of knowledge. Based on this writer's personal experience, individuals assigned to an ADP staff receive only on-the-job training. This, in turn, tends to perpetuate local misconceptions and biases. Even among the experienced ADP managers interviewed, there were some differing interpretations of policy. However, the major emphasis in the data was on the lack of knowledge among the ADPE users. Most of the users readily admit that they find the 300-series regulations, along with the procurement process and the budgeting cycle, to be very confusing. Even the initiating document, the DAR, can present problems. One ADP manager stated that a DAR typically has to be re-written twice before the user has accomplished it properly. These responses lead to the conclusion that there is a lack of training/knowledge about the ADP acquisition process among ADPE users and, at least, newly assigned ADP management personnel.

The data also indicate a possible lack of knowledge about advanced ADPE technology among high level management personnel. Several base level management personnel felt that policy making officials at HQ USAF and higher levels do not understand or appreciate the rapid changes that are occurring in ADPE technology. A task team within the Federal Data Processing Reorganization Project

examined ADP management in the human resource agencies of the government (Health, Education and Welfare, Veterans Administration, etc.). A Datamation article indicates the following draft findings and conclusions:

> Finding: The view that computers are only electronic accounting machines is still prevalent in Federal agencies.
> Finding: Adequate training programs for ADP managers do not exist in the Federal Government.
> Conclusion: The lack of adequate training programs to keep ADP managers current with the state-of-the-art lead to obsolescence of the individual, and eventually to obsolescence of the organization.
> Conclusion: The attitudes of agency managers are not conducive to innovative use of ADP. (McLaughlin, 1978:151)

It must be emphasized that DOD was not studied by this task team and that the above findings and conclusions cannot therefore be applied directly to the AF and DOD. However, the results do provide some degree of corroboration to the opinions that high level government officials are not current with the state-of-the-art in ADPE technology. Based on these data, it can be concluded only that a reasonable possibility exists that high level management personnel are not current with the ADPE state-of-the-art. If this were true, DOD and AF might fail to take advantage of the full potential of ADPE. Further study of this issue is suggested.

Conclusions and Recommendations: Time Delays. While

the basic ADP acquisition policies are appropriate for small-scale ADPE, the high organizational levels at which these policies are operationally implemented constitutes a problem area. The most common and fervent complaints about ADPE acquisition concerned the time delays involved. The ADP managers and ADPE users interviewed felt that the time required for approval of a DAR was often inordinately long when such approval had to be obtained from higher organizational levels. The writer concludes there are two major causes of these time delays. First, ADPE acquisition approval authority has not been adequately decentralized to meet a rapidly changing ADPE environment. Second, there is a lack of knowledge/training about the ADPE acquisition process among ADPE users and a lack of comprehensive, standardized training for newly assigned ADPE management personnel.

It is recommended that reasonable thresholds of purchase and lease acquisition approval authority be delegated to unique ADPS managers. It is further recommended that limited approval authority be delegated to organizational levels below the MAJCOM, such as numbered air forces, logistic centers, and laboratories. The approval thresholds delegated to these lower organizational levels should be commensurate with the development requirements of their respective ADPS. It is recommended that the approval thresholds of the MAJCOMs be increased to match the change in the DPA

requirement by GSA. It is specifically recommended that the ADPS single manager approval limits in AFSC be increased to match the DPA thresholds.

Further, it is recommended that a short course in ADPE acquisition be taught periodically. This course should be designed for newly assigned ADP management personnel and ADPE users.

What is ADPE? A third category of common concern about small-scale ADPE acquisitions involves the question, What is ADPE? All of the base level ADP personnel indicated that they occasionally have to make a special determination on whether an item is or is not ADPE--and hence whether its acquisition must follow the 300-series regulation procedures. Usually, this decision is made locally. However, in nebulous situations, the matter can go to the MAJCOM or HQ USAF. In general, base level ADP managers do not consider this a serious problem.

Resolving this definitional issue is a serious problem to the user caught in one of these nebulous situations. Two such examples were discovered during this research. The first case involved the acquisition of a graphics systems which utilized a PDP minicomputer as a controller. The user first initiated acquisition under AFR 4-2 (office equipment). At the MAJCOM level, the AFR 4-2 administrators decided the acquisition should be under the ADPE regulations. However, the ADP management personnel determined the system did

not come under the 300-series regulations. Finally, the matter was referred to GSA, where it was decided the system did not fall under the ADPE category. The user said that about this time the audio-visual management personnel and the communications control personnel got involved. He had to complete their paperwork in addition to the paperwork already done under the 4-2 and 300-series regulations. At the time of the interview, this acquisition approval process had been going on for ten months and was still not complete. What troubled the user was that all the regulatory people agreed the system would save money and should be acquired. They just could not agree on how to classify the equipment and under what regulations it should be acquired. The second case of this nature involved the acquisition of microfiche equipment. This acquisition was delayed about six months while trying to determine if the equipment was ADPE.

The writer concludes that the basic cause of these situations is the rapidly expanding applications for small-scale ADPE and a lack of ADPE/non-ADPE classification guidelines in the ADP regulations. The increasing uses for microprocessors, microcomputers, and minicomputers are discussed in Chapter Two. As computers, especially microprocessors, become employed in less traditional applications, particularily as integral components of other systems, it is inevitable that questions should arise concerning the appropriate management classifications of such equipment. For example, should

a microprocessor built into a microwave oven be acquired and managed under the 300-series regulations or is it so integral to the oven that one would not reasonably consider it ADPE? In this case the microprocessor and the oven are logically--and officially--classified as non-ADPE. However, in applications such as word processing, logical arguments can be made for and against considering the equipment as ADPE; the decision becomes very nebulous and arbitrary. This question of what is ADPE is being asked in private industry as well as in the Air Force. Frequent articles appear in the computer literature addressing aspects of this issue. Essentially, the rapid advances in the computer field make it virtually impossible to sharply define what is or is not ADPE. Under these circumstances, an organization can only establish reasonable guidelines and try to make consistent decisions.

Within the federal government, the classification of property is assigned by law to GSA. GSA carries out this function by evaluating items and assigning them to a Federal Supply Schedule (FSS) Group--Group 70 is ADPE. Of course, GSA cannot evaluate and classify every product manufactured. Rather, definitions and guidelines are issued to assist in classification of items not appearing on the FSS. The definition of ADPE in AFR 300-2 is modeled after GSA guidelines. Similar definitions of ADPE appear in the FPMR, the FPR, and DOD Directives. In situations where an agency is unable to satisfactory

classify an item, GSA is consulted for a final determination.

Within the Air Force, the pertinent issue, then, is whether ADP managers at the base and MAJCOM levels understand this classification procedure and apply it uniformly. The interview data collected indicate a significant degree of misunderstanding and lack of uniformity. The two examples discussed above, the graphics system and the microfiche equipment, illustrate how the ADPE/non-ADPE question can be argued between staffs for months. In addition to these two examples, several other situations were encountered where different policies were used in making the ADPE/non-ADPE determination.

One case involves two software development systems at different bases. Each of these systems is composed of several microcomputers. From the descriptions given, both appear to be very similar items used for similar purposes. However, one of the systems was classified as ADPE while the other was not. The reason given for the non-ADPE decision was that the system was not used for general data processing.

Similar reasoning was used at another base in classifying a word processing system as non-ADPE. The system utilized a full-size, commercially available minicomputer, with 96K of memory, as a controller. This was excluded from the 300-series regulations because it is not used for general data processing, rather it only replaces typewriters.

Even in cases where HQ USAF has provided specific guidance, different practices occur at the base level. One such case involves the calculator (non-ADPE) or computer (ADPE) question. HQ USAF has issued several letters designating specific calculator/computer type machines as ADPE. At one base if a machine which fell in this nebulous area was not listed in the HQ USAF letters then it was classified as non-ADPE. At another base a local policy had been inferred from the letters. This policy focused on whether the machine utilized a higher-order language and had significant input/output capabilities. At still another base, a policy had been inferred which focused on the amount of memory the machine had.

The question arises as to why this confusion and lack of uniformity exists. This writer concludes that it is due to lack of clarity in the regulations and a lack of standardized training. AFR 300-2 defines ADPE; this definition is reproduced in Appendix A. The first paragraph of the basic definition is as follows:

> 11. Automatic Data Processing Equipment [ADPE]. General purpose, commercially available automatic data processing components and the equipment systems created from them, regardless of use, size, capacity, or price, which are designed to be applied to the solution or processing of a variety of problems or applications, but which were not specifically designed (as opposed to configured) for any specific application.

A basic flaw in this definition is that it uses the term "automatic data

processing components: to define "automatic data processing equipment." The reader must make a decision on what constitutes automatic data processing components based on his technical background. Notwithstanding this, the definition does clearly refute the logic used by some base ADP managers in making the ADPE/non-ADPE decision. The most common argument used to exclude a particular item was that, "It is not used for general data processing." However, the definition seems to clearly specify that "use" is not a consideration.

Part of the trouble is that the regulations do not state any guidelines on how to determine if an item is ADPE; rather, guidance has been provided in the form of policy letters. During an interview, a HQ USAF official indicated the following process should be used in making an ADPE/non-ADPE decision. First, determine if the item--make and model--is classified on an FSS Group. If the item is in Group 70 then it is ADPE. If the item is in Group 70 and also in another Group, then treat it as ADPE. If the item is not in Group 70 and is in another Group then it is not ADPE. If the item is not classified in any GSA group, then objectively compare characteristics of the item with similar items on the FSS. Try to objectively decide where GSA would classify the item. If unable to make a logical decision then consult with higher commands. Eventually the case may have to go to GSA.

This procedure is not described in the 300-series regulations. The only guidance in addition to the definition in AFR 300-2 is found in AFM 300-6. Paragraph 1-3(b) states that questions as to whether equipment should be classified as ADPE should be referred to HQ USAF.

Conclusions and Recommendations: What is ADPE? As a result of rapid advances in computer technology, small-scale ADPE is being utilized in many non-traditional applications. Computer components, especially microprocessors, are becoming such integral components of larger systems that serious questions are arising concerning the classification of these items as ADPE. In many situations, logical arguments can be made for or against classifying a particular item as ADPE. The writer concludes there is no definitive technical answer to the question, What is ADPE? It can only be recommended that rational guidelines be applied as uniformly as possible throughout the Air Force.

At present, such guidelines are not being uniformly applied at the base level in the Air Force. As a result some acquisitions are being needlessly delayed causing a loss of time and money. The 300-series regulations do not provide adequate guidance on how to classify items as ADPE/non-ADPE. The policy guidance from HQ USAF on this subject has not been adequately understood by lower level personnel. It is recommended that further guidance be issued by HQ USAF.

It was previously recommended that a short course in ADP management be taught periodically. Such a course would be of significant assistance in achieving uniform application of ADPE classification policy.

Management

Having identified and analyzed problems involving ADPE acquisition, the discussion now focuses on issues concerning the management of small-scale ADPE. The ADP management personnel interviewed did not express serious concern or identify any serious problems with small-scale ADPE management. While the mere mention of "acquisition" would elicit numerous opinions, the collection of data concerning management usually required very specific questioning. There are two probable reasons for this emphasis on acquisition. First, there is often a time pressure involved in an acquisition--a need to get the equipment so the user can accomplish his mission. Second, once the equipment is turned over to the user the ADP manager is only required to perform mechanical management functions such as inventory control and periodic reports.

Although the interview data does not indicate serious concerns over small-scale ADPE management, several issues were discussed. Three of these issues will be briefly described. These are 1) orientation of the ADPE management regulations, 2) the ADPE inventory,

and 3) resource sharing. Then a determination is made as to whether advances in ADPE technology have rendered present ADPE management policies inappropriate for small-scale ADPE.

Orientation of the Regulations. The opinion was commonly expressed that AFM 300-6, the primary regulation on ADPE management, is oriented toward applications such as the Burroughs 3500/4700 operation. That is, the regulation is oriented toward a large standardized business or commercial type application, rather than small scientific applications. Even an official at HQ USAF stated that many parts of AFM 300-6 are not really applicable to small computers.

A review of AFM 300-6 does indicate that sections of the regulation do not seem applicable to small-scale ADPE, especially scientific or unique uses. For example, Chapter Three covers the management of a data processing installation. It discusses issues such as alternate site agreements and the development of management indicators to measure productivity. Other chapters cover the maintenance of records and ADP management reports. In a number of instances, exemptions from these AFM 300-6 requirements are allowed. Actually, it is only reasonable that AFM 300-6 would be oriented toward large, standard computer operations rather than attempting to cover the myriad situations involving small-scale ADPE.

In summary, while AFM 300-6 is primarily oriented toward

the large, standardized type of computer operation, this is not considered a serious problem by the persons interviewed.

ADPE Inventory. ADP manager's concerns about the ADPE inventory were closely related to the question of what is ADPE. The confusion that exists about the classification of ADPE naturally extends to the inventory once an item is procured. The ADPE inventory requirements are discussed in Chapter Four of this thesis. As described there, the regulations essentially require all items defined as ADPE to be included on the inventory.

The complaints made concerning the inventory focused on the rationale of keeping items questionably classified as ADPE on the records. One individual stated that the inventory should be kept pure. Others indicated that the regulations should permit the exemption of more items. The most unusual inventory situation encountered was in one MAJCOM where a separate inventory was maintained of equipment not officially classified as ADPE but which did contain or interface with ADPE. However, none of the persons interviewed seemed to consider the ADPE inventory a real problem. The probable reason for this is the relatively simple task of entering items on the inventory.

Resource Sharing. The ADP resource sharing program is described in Chapter Four. ADP management personnel were

questioned as to whether this program was applicable to small-scale ADPE. The opinions of two individuals seemed to summarize the answers to this question.

--Opinion of ADP administrator:

> Resource sharing is required where practical. This is handled on a situational basis. You have to consider both the cost of the equipment and the location of the users. If someone wanted to acquire a minicomputer and there was one already in his office or in the office next door, you certainly want to know why he could not use that one. However, if the closest one were several buildings away you should consider this also.

--Opinion of ADP administrator:

> Unfortunately there is too little sharing of resources. However, it must be remembered that often sharing can cost more than it saves with small ADPE. Why make users wait in line to utilize a low cost item?

Basically, ADP managers seem to take a practical, middle-of-the road approach to this issue. While they want to conserve resources and prevent duplication, they must also consider the cost of the ADPE and the convenience of the user.

Are ADP Management Policies Appropriate for Small-Scale ADPE? Based on the data collected, it is concluded that technological advances in ADPE have not rendered the basic ADP management policies inappropriate for small-scale ADPE. It is logical that users be required to share ADPE when practical, that ADPE be reutilized

when feasible, and that inventory control and accountability be maintained. Basic management policies such as these are applicable to large-, medium-, and small-scale ADPE.

Chapter Summary

This chapter addresses the fourth sub-objective of this thesis research: identify and examine current problems in the acquisition and management of small-scale ADPE. This represents a major step in testing the hypothesis that technological advances have rendered the current ADP acquisition and management policies inappropriate for small-scale ADPE. This chapter is organized into two main sections. First, the problems and issues involving ADPE acquisition are discussed. Then, the management of small-scale ADPE is examined.

The acquisition of ADPE was a topic of major concern both in the literature surveyed and among the ADP managers and ADPE users interviewed. A cross-section of the data collected on the issue is presented in this chapter. The ADP managers and ADPE users interviewed generally felt that the basic ADPE acquisition policies as implemented by the DAR are worthwhile. Included among these basic policies are the requirements to analyze the need for ADPE, provide justification for the acquisition, evaluate alternatives, and to plan for implementation of the equipment. Also, the ADP managers

and users interviewed generally approved of ADPE acquisitions coming under the purview of ADP management personnel, rather than being left entirely to the user's control. Based on this data, it is concluded that the basic ADP policies are appropriate for small-scale ADPE.

While the basic ADPE acquisition policies are appropriate for small-scale ADPE, the interview data indicate that the procedures which implement these policies have not been adequately adjusted to meet the declining cost and increasing use of ADPE. Numerous complaints about ADPE acquisition approval under the 300-series regulations concerned the amount and the duplication of paperwork, effort, and time for low dollar value items. The two primary issues involved the amount of detail required in a DAR and the duplication of DARs for acquisition of similar items. It is concluded that the primary cause of these complaints is the declining price and increasing use of ADPE and the failure of the ADP regulations to clearly specify the DAR documentation required for low cost items. It is recommended that a mini-DAR be permitted for low dollar value acquisitions. The 300-series regulations should clearly specify the required contents of this document. Also, it is recommended that a blanket DAR be tested on a trial basis.

A second problem area in small-scale ADPE acquisition is the centralization of acquisition approval authority. The most common and fervent complaints about ADPE acquisition concerned the time

delays involved. The ADP managers and ADPE users interviewed felt that the time required for approval of a DAR was often inordinately long when such approval had to be obtained from higher organizational levels. The writer concludes there are two major causes of these time delays. First, ADPE acquisition approval authority has not been adequately decentralized to meet a rapidly changing ADPE environment. Second, there is a lack of knowledge/training about the ADPE acquisition process among ADPE users and a lack of comprehensive, standardized training for newly assigned ADPE management personnel.

It is recommended that reasonable thresholds of purchase and lease acquisition approval authority be delegated to unique ADPS managers. It is further recommended that limited approval authority be delegated to organizational levels below the MAJCOM, such as numbered air forces, logistic centers, and laboratories. The approval thresholds delegated to these lower organizational levels should be commensurate with the development requirements of their respective ADPS. It is recommended that the approval thresholds of the MAJCOMs be increased to match the change in the DPA requirement by GSA. It is specifically recommended that the ADPS single manager approval limits in AFSC be increased to match the DPA thresholds.

Further, it is recommended that a short course in ADPE acquisition be taught periodically. This course should be designed for newly assigned ADP management personnel and ADPE users.

A third problem area in small-scale ADPE acquisition involves the question, What is ADPE? As a result of rapid advances in computer technology, small-scale ADPE is being utilized in many non-traditional applications. Computer components, especially microprocessors, are becoming such integral components of large systems that serious questions are arising concerning the classification of these items as ADPE. In many situations, logical arguments can be made for or against classifying a particular item as ADPE. The writer concludes there is no definitive technical answer to the question, What is ADPE? It can only be recommended that rational guidelines be applied as uniformly as possible throughout the Air Force.

At present, such guidelines are not being uniformly applied at the base level in the Air Force. As a result some acquisitions are being needlessly delayed causing a loss of time and money. The 300-series regulations do not provide adequate guidance on how to classify items as ADPE/non-ADPE. The policy guidance from HQ USAF on this subject has not been adequately understood by lower level personnel. It is recommended that further guidance be issued by HQ USAF. It was previously recommended that a short course in ADP management be taught periodically. Such a course would be of significant

assistance in achieving uniform application of ADPE classification policy.

Data were collected and analyzed on the topic of ADPE management as well as ADPE acquisition. While some minor problems occur in areas such as inventory control and resource sharing, the interview responses did not identify any serious problem involving the management of small-scale ADPE.

VII. The Effect of Small-Scale ADPE on the ADP Management Program and the Effect of the ADP Management Program on Small-Scale ADPE

This chapter addresses the last two sub-objectives of this research effort. These are 1) determine the major effects small-scale ADPE is having on the ADP management program, and 2) determine the effect that the ADP management program is having on Air Force utilization of small-scale ADPE. The mutual effects between small-scale ADPE and the ADP management program have been alluded to in previous chapters. The purpose of this chapter is to summarize and clarify these effects. Because of this close relationship to prior sub-objectives, much of the analysis for these two sub-objectives is built upon previously presented data and conclusions.

What Effect is Small-Scale ADPE Having on the ADP Management Program?

The fifth sub-objective of this thesis research is now addressed: determine the major effects small-scale ADPE is having on the ADP management program. This presentation is organized into three parts. First, some representative data on the topic are presented. Then, the effects of small-scale ADPE on the ADP management program are analyzed. Finally, some conclusions are stated.

Data.

--Opinion of base level ADP administrator:

> The volume of acquisitions exceeds the capacity of the system resulting in delays and problems.

--Opinion of base level ADP administrator:

> The small computers are becoming so inexpensive that the 300-series controls have reached the point of diminishing returns.

--Opinion of base level ADP administrator:

> The increasing use of small computers is making it tough on ADP management.

--Article in Government Executive:

> The basic groundrules were written in 1965 around 1965 technology. ("The Federal ADP Procurement Maze," 1977:49)

--Brooks committee report:

> . . . immediate cost benefits and time savings can be realized through the institution of simplified procedures for procurement of low dollar value items. . . . the resources of user agencies have been unfairly taxed by their being required to follow the same procedures for small dollar items as they must for major procurements. (House Report No. 94-1746, 1976:12)

Analysis. The aim of this analysis is to determine the effects small-scale ADPE is having on the ADP management program. To accomplish this requires the synthesis of three previous sub-objectives. First, the technological assumptions upon which the ADP

management program was founded are reviewed. Then, the changes in ADPE since that time are discussed. Finally, the ADPE acquisition problems that have resulted are examined.

Automatic data processing management in the federal government is founded on P.L. 89-306. This law provides the basic structure and concepts for the government-wide program of ADP management. An examination of the legislative history of P.L. 89-306 reveals that the centralization concept of ADPE acquisition and management was based to a significant degree on two technological assumptions. These were 1) the extensive use of large, centralized computers and timesharing, and 2) ADPE compatibility and standardization. The significance of these assumptions is that a relatively few, large, standardized computer systems could logically and reasonably be centrally procured and managed.

While timesharing computer systems did develop and are still widely used, two other types of computers also developed--the minicomputer and the microcomputer. When a bill embodying the concepts of P.L. 89-306 was first introduced in Congress in 1963, minicomputers were still in the embryonic stage and microcomputers did not exist. The minicomputer trend really began in 1965 with the introduction of the PDP-8. From 1966 to 1971, minicomputer prices declined 20% to 30% each year, while the cost/performance ratio improved by two orders of magnitude. The low cost and high

performance of these machines made them very popular. From 1965 to 1975, the number of minicomputers in the government's ADPE inventory increased about 22% each year. By 1975 minicomputers comprised over half of the government's computer inventory. In 1972, microprocessors and microcomputers became commercially available. In the following six years these machines improved to where their performance now rivals minicomputers. While no figures are available on the number of microprocessors and microcomputers in the federal inventory, indirect data gathered during this thesis research indicates a growing use of these machines.

The shift in trends from timesharing to small-scale ADPE, coupled with only limited success in the government's standardization effort, has resulted in the introduction of thousands of low cost, non-standardized ADPE items into a system originally designed for the centralized acquisition of a relatively few large computer systems. It would be simplistic to blame current ADP problems solely on these technological changes; however, as discussed in the previous chapter, the trend towards small-scale ADPE has contributed significantly to some of the problems. For example, it was concluded that a primary cause of acquisition time delays was a failure to adequately decentralize acquisition approval authority to meet a changing ADPE environment. Thus, a 1976 Congressional report found that 56% of all DPAs issued by GSA in 1975 were for acquisitions of $250,000 or

less. Most of these procurements were for minicomputers, peripherals, software, and maintenance. As the report concluded, " . . . the resources of user agencies are being unfairly taxed by their being required to follow the same procedures for small dollar items as they must for large procurements." (House Report No. 94-1746, 1976:12) Also, as discussed in the previous chapter, the declining costs of ADPE has effected the amount of paperwork and justification that is reasonable for an acquisition. Innovative procedures such as the mini-DAR and blanket DAR are needed to keep acquisition costs commensurate with the cost of the items being procured. In summary, the changes in ADPE technology have effected the implementation of the basic ADPE acquisition policies. The increasing number of small-scale ADPE acquisitions has slowed the acquisition approval process and the declining cost of ADPE has effected the amount of justification and paperwork that is reasonable for an acquisition.

Conclusion: Effect of Small-Scale ADPE on the ADP Management Program. While it would be simplistic to blame current ADP problems solely on technological changes, the trend toward small-scale ADPE has contributed significantly to some of the problems. The shift in trends from timesharing to small-scale ADPE has resulted in the introduction of thousands of low cost, non-standardized ADPE items into a system originally designed for the centralized acquisition of a relatively few large computer systems. This change in ADPE

technology has affected the implementation of the basic ADPE acquisition policies. The increasing number of small-scale ADPE acquisitions has slowed the acquisition approval process and the declining price of small-scale ADPE has effected the amount of justification and paperwork that is reasonable for an acquisition.

Effect of the ADP Management Program on Air Force Utilization of Small-Scale ADPE

The sixth sub-objective of this thesis research is now addressed: determine the effect that the ADP management program is having on Air Force utilization of small-scale ADPE. Representative data on this issue is presented below, followed by an analysis.

Data.

--Opinion of base level ADP administrator:

> The ADP management program is definitely inhibiting the innovative use of small-scale ADPE.

--Opinion of ADPE user:

> By and large the acquisition requirements hinder the innovative use of small ADPE.

--Opinion of ADPE user:

> The present ADPE acquisition requirements can be a very discouraging hurdle to a user. A manager typically faces many problems and has many demands on his time. When he sees all the ADPE acquisition problems he may just put his ADPE acquisition on the bottom of his list.

--Opinion of MAJCOM ADP administrator:

> The extensive justification and high bureaucratic level of approval required for ADPE acquisitions discourages the procurement of minicomputers and microcomputers.

--Article in Datamation magazine:

> In its June report to the President, the reorganization team also complained of the almost universal difficulty of getting information systems implemented within the EOP. One major stumbling block, they claimed, was "over control. The heavy emphasis on cost justification," they explained, "results in new languages (e.g., data base management systems), new implementation techniques, advanced equipment (e.g., virtual storage systems, distributed systems, dedicated systems for special functions such as word processing) not being available until the need for them is absolutely clear. This coupled with the long and arduous procurement process," they concluded, "means that the tools needed for information system development are often unavailable." (Flato, 1978:190)

--Congressional Hearing, 1976: Statement by Mr. Peter McCloskey, President, Computer Business Equipment Manufacturers Association:

> The unfortunate truth is that over the past 10 years, the Federal Government has fallen from a position of leadership in the utilization of ADP technology to a point where--with the possible exception of a few scientific agencies--it lags far behind the private sector.
>
> One evidence of this lag is found in the fact

> that only about 32 percent of the equipment listed in GSA's Federal ADP inventory incorporates technology utilized in ADPE currently being produced; whereas 68 percent of the inventory consists of products which are no longer being manufactured and are becoming obsolete.
>
> By contrast, a survey by a CBEMA member indicated that private sector presents a reverse image: about 74 percent of its inventory incorporates current technology, with only 26 percent consisting of equipment no longer in production.
>
> In an industry where technology has advanced with unbelievable rapidity--where in two short decades the cost of multiplication has been reduced by 126 times and where a shrunken dollar nonetheless buys 44 times the memory capacity--an obsolete equipment base is extremely costly.
>
> The cost of obsolescence can be measured in any number of ways: in excessive personnel expenses, in poor utilization of space, in subpar performance of the basic mission, and so forth.
>
> This problem was comprehensively analyzed in the Defense Department's blue ribbon panel report, which concluded that the use of obsolete computer technology, even assuming no cost of ownership, may result in substantially higher costs than procuring new equipment to perform the same job. (House Legislative and National Security Subcommittee, 1976:190, 191)

Analysis. The data collected from the interviews and literature generally indicate that the ADP management program tends to discourage innovative use of small-scale ADPE. The ADPE users

interviewed mentioned the complexity, time delays, and paperwork requirements of the acquisition process as being detering factors. Another factor mentioned in one interview and in the Datamation article quoted above is an emphasis on cost justification. As stated in the article, this results in advanced equipment not being available until the need for it is absolutely clear. A similar finding was made in a 1971 report by the Interagency Committee on Automatic Data Processing:

> Executive Agencies seem to have been so diverted in purpose or constrained by externally imposed concern with direct economy of ADP acquisitions and operations that they do not feel free, and therefore fail to pursue the best use of the ADP technology. ("Report of a Task Force on Long-Range Plans for ADP in the Federal Government," 1971:34, 35)

It should be stressed that only one individual interviewed explicitely stated there was too much emphasis on tangible cost justification under the 300-series regulations. AFR 300-2, paragraph 4f(5) does permit intangible benefits accruing from improved performance to be considered in approving an acquisition, provided " . . . there is confidence that the proposed automation will achieve all or most of the desired benefits."

However, the interview responses do generally indicate that ADPE acquisition requirements and attendant problems tend to discourage the prospective user. In several interviews, comments

were made that the Air Force's use of general purpose ADPE tends to lag the state-of-the-art. This is corroborated by the statement of Mr. Peter McCloskey (presented above in "Data") that 68% of the federal ADPE inventory in 1976 consisted of products no longer being manufactured. While there are undoubtedly many causes of this, it seems likely that the ADPE acquisition requirements are a contributing factor. Based on the interview and literature data, it is concluded that the time delays, complexity, paperwork, and cost justification requirements of the ADP management program tend to discourage the acquisition and innovative use of small-scale ADPE.

Chapter Summary

This chapter addresses the fifth and sixth sub-objectives of this thesis research. These are 1) determine the major effects small-scale ADPE is having on the ADP management program and 2) determine the effect the ADP management program is having on Air Force utilization of small-scale ADPE. It is concluded that small-scale ADPE is having a significant effect on the ADP management program. While it would be simplistic to blame current ADP problems solely on technological changes, the trend toward small-scale ADPE has contributed significantly to some of the problems. Furthermore, it is concluded that the time delays, complexity, paperwork, and cost justification requirements of the ADP management program tend to discourage the acquisition and innovative use of small-scale ADPE.

VIII. Conclusions and Recommendations

The analysis performed in the preceeding chapters has been directed toward testing the hypothesis that technological advances in ADPE have rendered the current ADP acquisition and management policies inappropriate for small-scale ADPE. To synthesize this previous analysis, an overall introduction and a summary of each sub-objective are presented below. It is felt that this organization will provide a systematic approach to reaching a conclusion about the hypothesis.

Introduction

In 1965, Congress passed Public Law 89-306 establishing a government-wide automatic data processing management program. The purpose of this program was to provide for the economic and efficient acquisition, utilization, and management of ADPE. However, in the 13 years since passage of the law, technological advances have significantly changed the capabilities, cost, and applications of the ADPE. Previous studies and the writer's own experiences in ADPE management indicated that problems exist in the acquisition and management of small-scale ADPE.

Based on initial research, it was hypothesized that these

problems occur because technological advances in ADPE have rendered the current ADP acquisition and management policies inappropriate for small-scale ADPE. The overall objective of the thesis is to test this hypothesis. To accomplish this, six sub-objectives were specified:

1. Identify the major changes that have occurred in ADPE technology, costs, capabilities, and applications since 1965 and the projected changes in the next 5-10 years.
2. Determine if the present ADP management program was based on particular technological assumptions.
3. Identify the major requirements under the present ADP management program for the acquisition and management of ADPE.
4. Identify and analyze current problems and issues in the acquisition and management of small-scale ADPE.
5. Determine the major effects small-scale ADPE is having on the ADP management program.
6. Determine the effect the ADPE management program is having on AF utilization of small-scale ADPE.

The results, conclusions, and recommendation formulated during this research effort are summarized below in relation to these sub-objectives.

Changes in Computer Technology

The purpose in examining computer history is to identify and illustrate the changes that have occurred in ADPE technology since the early 1960's when P.L. 89-306 was first proposed. A bill embodying the concepts of P.L. 89-306 was first introduced in Congress in 1963. This was during the second generation of computer technology. During this period the prevalent trend in computing was toward timesharing and the use of large central computers to serve scores of users. Another important trend was increasing hardware compatibility among ADPE manufacturers. It is important to note the situation in small-scale ADPE at this time--minicomputers were in the embryonic stage and microcomputers did not exist.

The evolution of small-scale ADPE began with integrated circuitry and the third computer generation. Integrated circuits offered the low cost, small size, and increased speed to make small computers successful. The minicomputer trend really began in 1965 with the introduction of the PDP-8. From 1966 to 1971, minicomputer prices declined 20% to 30% each year, while the cost/performance ratio improved by two orders of magnitude. The low cost and high performance of these machines made them very popular. In 1970, there were about 24,500 minicomputers installed in the United States. By 1975, this number had increased to 137,000. Also, by 1975, minicomputers comprised over half of the government's computer inventory.

In 1972, microprocessors and microcomputers became commercially available. In the following six years, these machines improved to where their performance now rivals minicomputers. The performance, cost, and size of microprocessors and microcomputers make these machines extremely useful. "The potential applications of microprocessor technology are so numerous that it is hard to visualize any aspect of contemporary life that will escape its impact." (Toong, 1971:160)

The progress in small computers is expected to continue unabated for the next five to ten years. During the next decade, the cost/performance ratio of computers is expected to increase by a factor of 100.

> By 1985, according to C. Lester Hogan, vice chairman of Fairchild Camera and Instrument Corp., it will be feasible to build a pocket calculator 'that will be more powerful than, and almost as fast as,' the $9 million Cray-1 built by Cray Research Inc., in Chippewa Falls, Wis., and recognized as the mightiest computer in the world. (The Age of Miracle Chips, 1978:51)

ADP Management Program--Technological Assumptions

Automatic data processing management in the federal government is founded on P.L. 89-306. This law provides the basic structure and concepts for the government-wide system of ADP management. It is implemented within the Air Force by the

300-series of regulations. The purpose in examining P.L. 89-306 is to determine if the ADP management program was founded on any particular technological assumptions.

An examination of the legislative history of P.L. 89-306 reveals that the centralization concept of ADPE acquisition and management established by the law was based to a significant degree on two technological assumptions. These were 1) the extensive use of large centralized computers and timesharing, and 2) ADPE compatibility and standardization. The significance of these assumptions is that a relatively few, large, standardized computer systems could logically and reasonably be centrally procured and managed.

The ADP Management Program--Requirements

The acquisition and management of ADPE within the federal government is controlled by a complex hierarchy of regulations. The capstone of this hierarchy is Public Law 89-306 which provides the basic structure and concepts for the government-wide system of ADP management. In the Executive branch this law has been implemented through the promulgation of special rules by the Office of Management and Budget (OMB), the General Services Administration (GSA), and the individual federal agencies. Within this last category, the Department of Defense (DOD) has issued a series of directives, instructions, and manuals, and the Secretary of the Air Force (SAF)

has published a series of orders dealing with ADPE.

These DOD and SAF rules are implemented within the Air Force by the 300-series of regulations. These regulations cover a wide range of ADP issues from acquisition and management to planning, programming languages, security, and privacy. Three of these regulations are particularly pertinent to this thesis investigation. AFR 300-2 established the Air Force Automatic Data Processing Program and prescribes the broad policies and responsibilities for acquiring and managing ADPE. Of special interest, it establishes the acquisition approval thresholds of the various ADP management levels. AFR 300-12 specifies the procedures an organization must follow in acquiring and implementing ADPE. The major acquisition requirements are implemented through the DAR document. Finally, AFM 300-6 provides guidance and establishes requirements for the operation and management of ADPE.

Small-Scale ADPE Acquisition and Management--Problems

The purpose of examining problems in small-scale ADPE acquisition and management is to determine whether inappropriate policies are causing these problems. The data for this analysis were collected from 23 interviews with ADP management personnel and ADPE users, supplemented by a literature review. From this data common issues of concern involving small-scale ADPE

acquisition and management were identified and analyzed.

The acquisition of ADPE was a topic of major concern both in the literature surveyed and among the ADP managers and ADPE users interviewed. The ADP managers and ADPE users interviewed generally felt that the basic ADPE acquisition policies as implemented by the DAR are worthwhile. Included among these basic policies are the requirements to analyze the need for ADPE, provide justification for the acquisition, evaluate alternatives, and to plan for implementation of the equipment. Also, the ADP managers and users interviewed generally approved of ADPE acquisitions coming under the purview of ADP management personnel, rather than being left entirely to the user's control. Based on this data, it is concluded that the basic ADP policies are appropriate for small-scale ADPE.

While the basic ADPE acquisition policies are appropriate for small-scale ADPE, the interview data indicate that the procedures which implement these policies have not been adequately adjusted to meet the declining cost and increasing use of ADPE. Numerous complaints about ADPE acquisition approval under the 300-series regulations concerned the amount and the duplication of paperwork, effort, and time for low dollar value items. The two primary issues involved the amount of detail required in a DAR and the duplication of DARs for acquisition of similar items. It is concluded that the

primary cause of these complaints is the declining price and increasing use of ADPE and the failure of the ADP regulations to clearly specify the DAR documentation required for low cost items. It is recommended that a mini-DAR be permitted for low dollar value acquisitions. The 300-series regulations should clearly specify the required contents of this document. Also, it is recommended that a blanket DAR be tested on a trial basis.

A second problem area in small-scale ADPE acquisition is the centralization of acquisition approval authority. The most common and fervent complaints about ADPE acquisition concerned the time delays involved. The ADP managers and ADPE users interviewed felt that the time required for approval of a DAR was often inordinately long when such approval had to be obtained from higher organizational levels. The writer concludes there are two major causes of these time delays. First, ADPE acquisition approval authority has not been adequately decentralized to meet a rapidly changing ADPE environment. Second, there is a lack of knowledge/training about the ADPE acquisition process among ADPE users and a lack of comprehensive, standardized training for newly assigned ADPE management personnel.

It is recommended that reasonable thresholds of purchase and lease acquisition approval authority be delegated to unique ADPS managers. It is further recommended that limited approval authority

be delegated to organizational levels below the MAJCOM, such as numbered air forces, logistic centers, and laboratories. The approval thresholds delegated to these lower organizational levels should be commensurate with the development requirements of their respective ADPS. It is recommended that the approval thresholds of the MAJCOMs be increased to match the change in the DPA requirement by GSA. It is specifically recommended that the ADPS single manager approval limits in AFSC be increased to match the ADP thresholds.

Further, it is recommended that a short course in ADPE acquisition be taught periodically. This course should be designed for newly assigned ADP management personnel and ADPE users.

A third problem area in small-scale ADPE acquisition involves the question, What is ADPE? As a result of rapid advances in computer technology, small-scale ADPE is being utilized in many non-traditional applications. Computer components, especially micro-processors, are becoming such integral components of larger systems that serious questions are arising concerning the classification of these items as ADPE. In many situations, logical arguments can be made for or against classifying a particular item as ADPE. The writer concludes there is no definitive technical answer to the question, What is ADPE? It can only be recommended that rational guidelines be applied as uniformly as possible throughout the Air

Force.

At present, such guidelines are not being uniformly applied at the base level in the Air Force. As a result some acquisitions are being needlessly delayed causing a loss of time and money. The 300-series regulations do not provide adequate guidance on how to classify items as ADPE/non-ADPE. The policy guidance from HQ USAF on this subject has not been adequately understood by lower level personnel. It is recommended that further guidance be issued by HQ USAF. It was previously recommended that a short course in ADP management be taught periodically. Such a course would be of significant assistance in achieving uniform application of ADPE classification policy.

Data were collected and analyzed on the topic of ADPE management as well as ADPE acquisition. While some minor problems occur in areas such as inventory control and resource sharing, the data did not identify any serious problems involving the management of small-scale ADPE.

Effect of Small-Scale ADPE on the ADP Management Program

While it would be simplistic to blame current ADP problems solely on technological changes, the trend toward small-scale ADPE has contributed significantly to some of the problems. The shift in trends from timesharing to small-scale ADPE has resulted in the

introduction of thousands of low cost, non-standardized ADPE items into a system originally designed for the centralized acquisition of a relatively few large computer systems. This change in ADPE technology has affected the implementation of the basic ADPE acquisition policies. The increasing number of small-scale ADPE acquisitions has slowed the acquisition approval process and the declining price of small-scale ADPE has effected the amount of justification and paperwork that is reasonable for an acquisition.

Effect of the ADP Management Program on Air Force Utilization of Small-Scale ADPE

The ADP managers and ADPE users interviewed generally indicated that the ADP management program tends to discourage the acquisition and innovative use of small-scale ADPE. Factors which deter prospective users include time delays, complexity, extensive paperwork, and an emphasis on cost justification.

Have Technological Advances in ADPE Rendered the Current ADP Acquisition and Management Policies Inappropriate for Small-Scale ADPE?

The objective of this research effort was to determine whether technological advances in ADPE have rendered the current ADP acquisition and management policies inappropriate for small-scale ADPE. The ADP managers and ADPE users interviewed generally felt that the basic acquisition and management policies are appropriate

for small-scale ADPE. They indicated that basic acquisition policies as implemented by the DAR are reasonable and worthwhile. Included among these policies are the requirements to analyze the need for ADPE, provide justification for the acquisition, evaluate alternatives, and to plan for implementation of the equipment. Also, the personnel interviewed generally approved of ADPE acquisitions coming under the purview of ADP management personnel, rather than being left entirely to the user's control. Furthermore, the interview responses indicate general approval of the basic ADP management policies. Personnel interviewed consider it reasonable that users be required to share ADPE when practical, that ADPE be reutilized when feasible, and that inventory control and accountability be maintained. Basic management policies such as these are applicable to small-scale ADPE. The writer concludes that the basic ADP acquisition and management policies are appropriate for small-scale ADPE.

However, technological advances in ADPE are having a significant impact on the implementation of these basic ADP acquisition policies. The development and evolution of small-scale ADPE has introduced an increasing number of low cost acquisitions into a centralized acquisition system. Among the personnel interviewed, the most common and fervent complaints about ADPE acquisitions concerned the time delays involved. One cause of these delays is

that ADPE acquisition approval authority has not been adequately decentralized to meet a changing ADPE environment. Additionally, the declining cost of small-scale ADPE has effected the amount of paperwork and justification that is reasonable for an acquisition. Current procedures need to be simplified through means such as a mini-DAR and a blanket DAR. The expanding applications for ADPE have also raised the question, What is ADPE? While there is no definitive technical answer to this question, further guidelines need to be provided so that a uniform policy can be applied throughout the Air Force. In summary, although the basic ADP policies remain valid, the implementation of these policies has been significantly affected by the advent of small-scale ADPE.

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APPENDIX A

Definitions

A. Definitions

Automatic Data Processing Equipment [ADPE]

General purpose, commercially available automatic data processing components and the equipment systems created from them, regardless of use, size, capacity, or price, which are designed to be applied to the solution or processing of a variety of problems or applications, but which were not specifically designed (as opposed to configured) for any specific application. This includes:

a. Digital, analog, or hybrid computer equipment;

b. Auxiliary or accessorial equipment such as data communications terminals, source data automation recording equipment (for example, optical character recognition equipment and other data acquisition devices), data output equipment (for example, digital plotters), etc., to be used in substantial support of digital, analog, or hybrid computer equipment, either cable-connected, wire-connected, or self-standing and whether selected or acquired with a computer, or separately; and

c. Electrical accounting machines (EAM) used in conjunction with or independently of digital, analog, or hybrid computers.

d. For the purpose of this regulation, the above definition

excludes computer equipment which is integral to a combat weapons system when:

(1) It is physically incorporated into the weapon; or,

(2) It is integral to the weapons system from a design and procurement and operations viewpoint, or

(3) Separate selection, acquisition, and/or management of the computer equipment would be infeasible.

For the purpose of this regulation, being integral to a combat weapons system means being dedicated to and essential in the performance of the mission of the weapons system in combat; e.g., automatic combat command, control and communications processing for specific combat weapons. Computer equipment used for logistic or administrative support of a weapons system, or which can be selected and acquired from commercial product lines independent of other components of the weapons system, is not covered by this exclusion. For purposes of this definition, a combat weapons system is an instrument of combat either offensive or defensive, used to destroy, injure, or threaten the enemy. (AFR 300-2)

<u>ADP Personnel</u>

All government personnel, both civilian and military, who as their principal duty, are identified with ADP functions, including but not limited to:

a. ADP administration (for example, planning and coordinating ADP programs and activities; reviewing, recommending, or selecting ADPE; and approving the acquisition of ADP equipment or services).

b. Training.

c. Design, development, programming, and implementation of automated data systems.

d. Provision of ADP services on a consulting or project basis.

e. ADP operations (for example, ADPE operation and maintenance, keypunching, etc.).

Automated Data System [ADS]

An assembly of procedures, processes, methods, routines, or techniques (including, but not limited to computer programs) united by some form of regulated interaction to form an organized whole, specifically designed to make use of ADPE.

Automated Data Processing System [ADPS]

An aggregation of software and the resources required to support it (ADPE, manpower and facilities). The ADPS includes one or more ADS and generally has a distinct suit of hardware associated with it. An ADPS can be all ADSs and their supporting resources at a single activity, or all ADSs at a single type of activity, or it can be the ADS and its associated resources that support a single function at one or more activities, or an aggregation

of types of activity with a common function and/or mission, e.g., hospitals.

Managers

a. The Air Force ADP Program Single Manager. The Director of Data Automation, HQ USAF, was designated the Air Force ADP Program Single Manager by the Chief of Staff, and was redelegated the authorities delegated to the Chief of Staff by Secretary of the Air Force Order No. 560.1. Authority and responsibilities are established by this regulation. The procedures for implementing these responsibilities are set forth in this regulation and AFR 300-12, volume 1.

b. Command ADP Program Single Manager. The Director of Data Automation or comparable official at each MAJCOM/SOA designated by the commander thereof as the Command ADP Program Single Manager. Responsibilities are established by this regulation. Approval authorities prescribed herein constitute redelegation of authority by the Air Force ADPS. (Responsibilities and approval authorities are prescribed by this regulation.)

c. USAF ADPS Manager. The individual/organization responsible for management of a Standard ADPS, (Responsibilities and approval authorities are prescribed by this regulation.)

d. Command ADPS Manager. The individual responsible for

a command-unique ADPS.

e. Program or Project Managers. Individuals, from any functional or support organization who are assigned the responsibility for implementing actions or tasks related to the satisfaction of an ADP requirement. The design, development, test, implementation of ADS or ADPS and the acquisition of ADP resources are examples of such tasks. The responsibilities and authority of the program or project manager are specified by the governing directives. Management responsibility rests with either a program or a project manager during the development, acquisition, and test phases of a systems life. As an ADPS attains operational status, management responsibility shifts to an ADPS management organization.

f. Data Processing Installation (DPI) Manager. Individual charged with the responsibility for managing the operation of an automatic data processing installation.

g. Functional ADS manager. The individual responsible for management of assigned ADS(s). Specific responsibilities are as prescribed by this regulation.

"Small-scale" ADPE

As used in this paper, the term "small-scale" ADPE refers to a rather broad classification of ADPE and ADP-related devices ranging from the traditional minicomputer classification down

through microcomputers, word processing equipment, calculators, and equipment containing internal microprocessors. This term is intended to include ADP-related equipment which because of its application, cost, size, programmability, or other ADPE technological features is currently causing management problems or confusion under the AF 300-series regulations.

Standard ADPS

An ADPS that provides support to more than one major command or separate operating agency.

The USAF ADP Program

The sum of all objectives, plans, policies, directives, procedures, and criteria (including the time-phased schedules of events and resource requirements) establishing and pertaining to:

a. The acquisition, use, and management of ADP resources.

b. The design, development, control, improvement, and standardization of automated data systems.

Unique ADPS

An ADPS that provides support to one major command/separate operating agency.

APPENDIX B

Typical Interview Questions

B. Typical Interview Questions

1. Do you think the 300-series regulations are appropriate for small-scale ADPE?
2. Have you experienced any problems in applying the 300-series regulations to the acquisition of small-scale ADPE?
3. Do you think that at some point on the ADPE spectrum, the DAR process should be made simplier or optional?
4. Have you experienced any problems determining whether a piece of equipment should be classified as ADPE under the 300-series regulations? How do you normally resolve this question?
5. Do you feel you have adequate guidance from higher commands about what is or is not ADPE?
6. Have you experienced any problems where the application of a piece of equipment required its acquisition under a particular set of regulations, but the inclusion of ADPE, such as a micro-processor, within the equipment required its acquisition under the 300-series regulations?
7. Have you experienced any problems in the inventory control of small-scale ADPE?
8. Have you experienced any problems with the sharing of small-scale ADPE?

9. Do you think the Air Force would benefit by encouraging expanded use of small-scale ADPE?

10. What effect do you think the ADP management program has on the acquisition and utilization of small-scale ADPE?

11. Do you foresee the uses of small-scale ADPE increasing, remaining about the same, or shrinking?

12. Do you think the ADP management program can effectively and efficiently handle small-scale ADPE in the future?

13. Do you have any suggestions for improving the acquisition and management of small-scale ADPE under the 300-series regulations?

APPENDIX C

Classification of Personnel Interviewed

C. Classification of Personnel Interviewed

Total Personnel Interviewed	23
ADP Management Personnel:	
HQ USAF	2
MAJCOM Level	6
Base Level	8
ADPE Users	7

MAJCOMs Represented: AFSC, AFLC, MAC, ATC

APPENDIX D

Air Force 300-Series

Regulations and Manuals

D. Air Force 300-Series Regulations and Manuals

AFR 300-2:	Management of the USAF Automated Data Processing Program
AFR 300-5:	Standardization of Data Elements and Related Features
AFR 300-7:	Automatic Data Processing (ADP) Planning
AFR 300-8:	Security Requirements for Automatic Data Processing Systems (ADPS)
AFR 300-9:	Logistics Data Element Standardization and Management Program (LOGDESMAP)
AFR 300-10:	Computer Programming Languages
AFR 300-12: (Volume I)	Procedures for Managing Automated Data Processing Systems--Documentation, Development, Acquisition, and Implementation
AFR 300-12: (Volume II)	Procedures for Managing Automated Data Processing Systems (ADPS)
AFR 300-13:	Safeguarding Personal Data in Automatic Data Processing Systems
AFM 300-4:	Data Elements and Codes (Twelve Volumes)
AFM 300-6:	Automatic Data Processing (ADP) Resource Management

APPENDIX E

AFR 300-2 Acquisition

Approval Thresholds

LEVEL OF APPROVAL AUTHORITIES

1. Approval Authority. The authority to commit or acquire ADP resources under the Air Force ADP program is restricted to:

a. The Air Force Senior ADP Policy Official (SAF for Financial Management).

b. The Air Force ADP program single manager.

c. Command ADP program single managers.

d. USAF ADPS managers.

e. Command ADPS managers, under authority delegated by the Command ADP program single manager.

f. Program or project managers, under specific authority which may be delegated by a program or project directive.

2. Thresholds. The following table provides a summary of the approval authority thresholds for various types of acquisition and procurement under the Air Force ADP program:

a. The approval levels named in paragraphs 1c and e do not apply to WWMCCS and Air Force IDHS ADPS elements (except EAM lease); instead, those requirements are to be validated by the designated USAF ADPS manager in accordance with this regulation and AFR 300-12, volume 2.

b. Program and project managers exercise their approval authority as specified in the program or project directive.

c. As the Senior ADP Policy Official of the Air Force SAF for Financial Management retains approval authority for thresholds that exceed the approval authority of HQ USAF/KRA.

d. In item 7 below, the thresholds are in terms of individual contracts, and the costs are cumulative in each project.

Threshold [Thousands of $]	Paragraph	Approval Authority
1. ADPE Approval-Competitive Selection:		
a. Lease (annual costs):		
More than $100 but not more than $1,000 ($1 million)	12c(1)	HQ USAF/KRA
$100 and less	15b(2)	MAJCOM/USAF ADPS Manager
b. Purchase (total costs):		
$3,000 ($3 million) and less	12c(1)	HQ USAF/KRA
2. ADPE Approval-Sole Source:		
a. Lease (annual costs):		
More than $50 but not more than $200	12c(2)	HQ USAF/KRA
$50 and less per year	15b(1)	MAJCOM/USAF ADPS Manager
b. Purchase (total costs):		
$500 and less	12c(2)	HQ USAF/KRA
3. ADPE Approval-Re-Utilization:		
a. Lease (annual costs):		
$200 and less	12c(6)	HQ USAF/KRA
b. Owned Equipment:		
$500 and less	12c(6)	HQ USAF/KRA
4. ADPE Approval-EAM:		
a. Lease	15c	MAJCOM/USAF ADPS Manager
b. Purchase	12c(8)	HQ USAF/KRA
5. Expense Item Purchase:		
$1 and less	15d	MAJCOM/USAF ADPS Manager

Threshold [Thousands of $]	Paragraph	Approval Auhtority
6. ADS Development:		
Systems Design and Programming—Organic Manpower:		
Less than 25 man-years	15g	MAJCOM/USAF ADPS Manager
More than 25 but not more than 50 man-years	12c(7)	HQ USAF/KRA
7. ADP Contractual Services:		
More than $100 but not more than $500	12c(4)	HQ USAF/KRA
$100 and less	15a	MAJCOM/USAF ADPS Manager
8. Commercial Software Acquisition:		
a. Purchase (total costs):		
More than $50 but not more than $500	12c(5)	HQ USAF/KRA
$50 and less	15e	MAJCOM/USAF ADPS Manager
b. Lease (annual cost):		
More than $15 but not more than $200	12c(5)	HQ USAF/KRA
$15 and less	15e	MAJCOM/USAF

E. AFR 300-2 Acquisition Approval Thresholds

Additional delegation of purchase approval authority to AFSC and Air Force Technical Application Center (AFTAC) is addressed in AFR 300-2, paragraph 21.

Delegation of Purchase Approval Authority to AFSC and Air Force Technical Application Center [AFTAC]

The AFSC and AFTAC ADP program single managers are delegated purchase approval authority for ADPE, other than that covered by a PMD, funded from research, development, test and evaluation (RDT&E) (3600) appropriations, as follows:

a. Competitive acquisitions $100,000 and less.

b. Sole-source acquisitions $50,000 and less.

c. The additional limitations and instructions of paragraph 15b apply.

d. Copies of approved sole-source acquisition documents will be maintained for future review by HQ USAF.

APPENDIX F

<u>AFR 300-12 Instructions</u>

DATA AUTOMATION REQUIREMENT (DAR)

1. General Information. The originating organizations will forward the DAR to the appropriate approval authority with a cover letter that indicates the originating organization, parent command, preparation date, DAR number, contact point, and general statement of the requirement. The DAR will include information and supporting rationale necessary to provide an understanding of the ADP requirement and to permit consideration of alternative solutions. The format below will be used for all DAR preparation. The format is designed to facilitate staffing; therefore, paragraph sequence and organization will be maintained. If a paragraph does not apply, enter NA.

2. Format and Content:

a. **Executive Summary.** The originating office will prepare an Executive Summary to provide a brief discussion of the requirement, proposed solution, and funding requirements. In addition to direct budget related benefits, intangible benefits and improvements, which do not represent reductions in budget, frequently will occur as a result of automation or enhancements to automated operations. Examples of such intangible benefits/improvements are; productivity increases, improved accuracy, improved responsiveness (faster access to information), or increased employee satisfaction (reduced personnel turnover rate). Such intangible benefits/improvements have values, although these values do not represent budget reductions, they are real and can be estimated in dollars. These esimates, together with supporting rationale, will be provided in this section. These estimates will not be included in the economic analysis. DARs to be approved at MAJCOM/SOA level may omit the Executive Summary and Table of Contents.

b. **Table of Contents.** In accordance with the guidance in AFR 5-1, provide a Table of Contents if the document exceeds 10 typewritten pages.

c. **Justification Data.** This section provides the information on the requirement necessary to staff the DAR for approval. This data may be extracted from previously prepared documents.

(1) Heading. A short statement, centered at the top of the first page, all capital letters, which starts with "JUSTIFICATION FOR—" and is completed, as appropriate. Action, location, and equipment will be identified.

(2) Content:

Paragraph 1.	Purpose. Outline the nature of the request for ADP resources, such as, requesting approval for: ADPS/ADS development or modification, ADPE or software acquisition resources to accomplish a feasibility study, or contractual services. For acquisitions, state whether sole source or competitive. Specify any required installation or operational dates.
Paragraph 2.	Objectives. Provide a summary of the objectives as stated in the economic analysis.
Paragraph 3.	Background. State the mission of the OPR as it relates to the ADP requirements and key events that led to the requirements. Include s summary of the results of the critical analysis of the functional area requirement that led to the decision to automate.
Paragraph 4.	Workload. Proposed ADS applications; workload currently on installed ADPE; a schedule to support requirements; projected workload. Explain method of projecting workload and reliability of any factors used.
Paragraph 5.	Proposed ADPS or Its Elements. Explain current deficiencies. Explain the necessity of requested elements and identify assumptions and constraints. Identify the advantages of the proposal and how it is expected to fulfill the requirement for the life cycle. If applicable, indicate the future need to incrementally augment the planned ADPS; or, in the case of a major ADPS development effort with a planned system life cycle exceeding 8 years, indicate planning for incremental development, prototype, and phased subsystem deployment and use prior to full operational deployment. Include telecommunications requirements.
Paragraph 6.	ADS Development. Summarize data for each alternative from the economic analysis. Describe potential technical risks/benefits for each alternative.
Paragraph 7.	Equipment. Discuss all alternatives; include types, cost, source (see chapter 9).

Paragraph 8.	Costs and Benefits. Summarize cost data for each alternative. Describe rationale for selecting the recommended alternative (e.g., low cost, low level of risk, high-level technical advantage). Summarize detailed data from economic analysis for proposed alternative.
Paragraph 9.	Impact Statement. Stress economic and mission impact if recommended alternative is not approved. Explain why it is essential to take positive action at this time, rather than to maintain status quo.
Paragraph 10.	Funds. Are there funds to cover the requirement in the command program? If not, identify source of funding. State whether or not a PAR has previously been submitted IAW AFR 300-7 which identified a funding need to support the requirement.
Paragraph 11.	Additional Resource Requirements/Availability. Identify resource requirements and indicate if resources are within current approved program and targets established (resources may vary between alternatives).
Paragraph 12.	Major System Development Effort. Describe as a total system and identify major subsystem elements. Describe how the specific subsystems will be integrated into the overall system.
Paragraph 13.	Other Potential Application. Recommend additional applications of the preferred solution.
Paragraph 14.	Requirements Validation. This paragraph will provide a statement that the functional OPR has conducted a critical analysis of functional area requirements and that these requirements have been validated.
Paragraph 15.	Other Comments. Include additional information that will facilitate understanding and evaluating this DAR.
Paragraph 16.	Joint Signature Block.

Functional Area OPR (Validation of Functional Requirement)	ADP Program Single Manager or USAF ADPS Manager (Approved or Recommend Approval)

d. Attachments:

(1) Economic Analysis. Provide an Economic Analysis in accordance with chapter 3. Estimates may be used in the initial submission if the basis for the estimates is explained. The objective is to put the problem in perspective. The analysis may change substantially in subsequent iterations.

(2) Feasibility Study. (Required for all ADPS/ADS development efforts ecpected to exceed 10 man-years.) Additionally, feasibility studies are required for ADPE acquisitions wherein the anticipted cost will exceed $100,000 purchase or $30,000 annual lease. The feasibility study should be as comprehensive as resources permit and will serve as justification supporting the DAR. (See attachment 25.)

(3) ADP and Telecommunications Requirements Checklist. Provide data as indicated in attachment 23. This data must accompany all APRs which are submitted to GSA. The certifying official will be at the level of the Assistant Secretary of the Air Force (Financial Management); the Directorate of Data Automation, HQ USAF; the USAF ADPS managers; or the command ADP program single managers at MAJCOM/SOA. The certifying official will be the same as the approval level depicted in AFR 300-2. When the certifying official is at MAJCOM/SOA level all appropriate sections of the checklist must be completed and certified by the certifying official. When the certifying official is at HQ USAF or higher level all data required for certification (studies, funding information, privacy data and sharing information) will accompany the DAR submission. This will enable the certifying official to properly certify the checklist.

(4) Other. For example, graphs or tables may be attached if necessary, to adequately explain quantifiable data.

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A STUDY OF THE ACQUISITION AND MANAGEMENT OF SMALL-SCALE AUTOMA--ETC(U)
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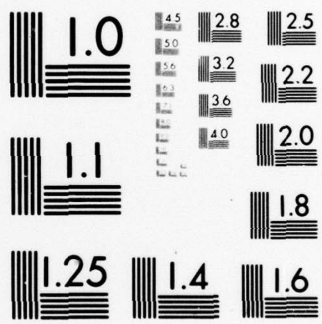
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DATA PROJECT DIRECTIVE (DPD)

1. General Information:

a. The DPD documents key decisions, assigns responsibilities, defines the project scope, and authorizes specific actions. The DPD is used to initiate, change, or terminate a data automation project under AFR 300-2. DPDs are developed by the Data Automation staff, with the assistance of the functional area OPR at the DAR approval level and are coordinated with all involved activities prior to being formally issued.

b. DPDs will be prepared in the format indicated below. The level of detail in the DPD will be commensurate with the scope and complexity of the project being directed. The paragraph sequence will be preserved. If an item is not applicable to a specific project, enter NA.

2. Format and Content:

a. **Use the title and number** of the related DAR and add the date.

b. **Objectives.** Clearly indicate the boundaries of the project to:

(1) Direct the development or modification of an ADPS or ADS, or any element thereof.

(2) Designate functional ADS managers, as deemed appropriate by the functional area.

(3) Appoint or direct the appointment of a Program or Project Manager (PM), responsible for design and development and implementation of the total ADPS or ADS.

(4) Direct the development of DPP.

(5) Conduct studies and/or requirement analyses to clearly identify a particular problem or deficiency.

(6) Develop documentation supporting a particular DAR.

(7) Direct actions relating to the selection and acquisition of ADPR.

(8) Provide technical, acquisition, and managerial guidance; ADPR approvals; and funding data related to the project.

(9) Delegate unique ADPR approval authority and establish dollar thresholds (e.g., when DPD is addressed to a PMO).

(10) Direct management/system reviews at selected milestones, to be performed by the PM with participation from HQ USAF/KRA representatives, other Air Staff functional area OPRs, or a uniquely qualified organization specifically designated to perform/participate in these types of reviews, when HQ USAF/KRA is the approval authority.

(11) Direct management reviews at selected milestones, to be performed by the command ADP program single manager organizations, USAF ADPS manager, and PMs when the ADP approval authority is at MAJCOM/SOA or USAF ADPS manager level.

c. **Project Participants and Tasking.** Identify the project participants and specify their responsibilities, including the preparation of the DPP. The following participants will normally be involved in most projects:

(1) The ADP program single manager with review responsibilities.

(2) The PMs. (The PMO responsibilities will include the approval authority delegated by HQ USAF.)

(3) The Functional OPR.

(4) The design/development/procurement and installation activity or activities.

(5) Telecommunications support activity.

(6) Logistics activities.

(7) Designated ADP security activity.

(8) The selection and acquisition activity.

(9) Members of the ADPE specification team (if required).

(10) The successor contracting officer.

(11) Training activities. (If ATC support is required, ATC/XPQ will be listed as a participant.)

(12) Manpower Activities.

d. **Special Requirements.** Criteria will vary, depending on the project's purpose, scope, cost, and complexity. Include the items below, if appropriate. (Other criteria may be added.)

(1) Legal, Policy, or Procedural Constraints. Indicate requirements to be satisfied. Specifically, include requirements that emanate from other Government agencies, DOD, or other Air Force functional areas. Include Treaties or Status of Forces Agreement with allied nations, if app opriate.

(2) Interface or Integration. Identify all ADPS and other systems that ʼ'l be affected. Define levels of interface and methods to be employed in achieving integration.

(3) Program/Project Management Relationship. Indicate the line of ma agement responsibilities (e.g., project manager to program manager within a PMO; program manager to or anizational commander, SOA, and to command ADP program single manager and the Air Force ADP prog am single manager (HQ

USAF/KRA), and program manager to functional OPR.

(4) Security. Indicate the security protection of the project that may be required.

(5) Prototyping.

(6) ADPE.

(7) Site Preparation.

(8) Communications.

(9) Software/Computer Program.

(10) Training and Support.

(11) Configuration Management.

(12) Privacy.

(13) System Review and Related Reporting.

(14) Designate or require designation of user/representative(s) who is authorized to act in the name of the user in the conduct of system reviews and audits.

e. **Financial/Resource Considerations.** Include PEC and Element of Expense Identification Code that provides resources, if known, and funding limitations, if appropriate.

f. **Significant Milestones Anticipated in the Development Schedule.** Appropriate milestones and related reporting criteria will be provided in accordance with chapter 3. These milestones will be refined in the DPP. Applicable management reviews and audits will be identified in accordance with chapter 4. Identify those significant milestones which require updating of the economic analysis.

g. **Other Considerations.**

h. **Signature Block:** Issuing authority.

DATA PROJECT PLAN (DPP)

1. General Information. The DPP will:

a. Implement the requirements of paragraph 2-7.

b. Provide appropriate data from the pertinent DAR and DPD as modified or expanded by additional facts that have become available after publication of the DPD. Some of the items requires in the DPP can be obtained from the economic analysis prepared as specified by chapter 3.

c. Follow the organizational sequence outlined below.

2. Format and Content:

a. **Identification.** Use the title and number of the implementing DPD and add the date.

b. **Objectives:**

(1) Statement of the project objectives.

(2) Quantification of the objectives.

(3) Criteria to be used in measuring the extent to which objectives are met.

(4) Indication of when the objectives will be measured.

(5) Stipulation of how the results of the measurement will be documented.

c. **Reporting System and Schedule.** Include a control and reporting system such that:

(1) The Master Milestone Schedule is identified, together with all tasking, actions, cost, savings, and benefits (by milestones).

(2) The actual accomplishments, by milestone, as to tasks completed, man-hours expended, costs incurred and the progress relative to the schedule are easily associated and deviations are readily visible.

(3) The milestone reporting requirements chapter 3, (section C) are implemented.

(4) Slippage in schedule is reported in terms of the impact on costs, savings, and benefits. (Alternative actions should be presented, including man-hours and costs required to recover and complete the project.)

d. **Constraints/Limitations.** Relate to DPD.

e. **ADPS/ADS Development Planning.** Develop and document supporting plans as appropriate. Identify the OPR and participants for each action. Identify the required support, and the actions, schedules and resources necessary to provide the support. The following plans will be summarized in this section and the individual plans attached as appendices.

(1) ADS Design Plan.

(2) ADPS Test and Evaluation Plan.

(3) ADS Documentation Plan.

f. **Selection and Acquisition Planning.** Identify the OPR and participants for each action. Identify the actions, schedules, and resources necessary to provide the required support. The Selection and Acquisition Plan will be summarized in this section and the plan will be attached as an appendix.

g. **Implementation Plan.** Identify the required support, technical criteria, and the actions, schedule, and resources required to provide the necessary support. Develop an Implementation Plan that provides tasks, OPR, and schedules for total project development and implementation. This must include the minimum required reviews and audits. Identify the OPR and participants for each action. The following annexes, as appropriate, will be summarized in this section and attached to the Implementation Plan.

(1) ADPS/ADS Conversion.

(2) Logistics Support.

(3) Training.

(4) Communications.

(5) Site Preparation.

(6) Security.

(7) Manpower.

h. **Configuration Management Plan.** (See attachment 20.)

i. **Other.** Any other plans, schedules, or information considered appropriate by the project manager.

VITA

Captain Donnie B. Self was born on May 4, 1951, in Birmingham, Alabama. He graduated from high school in Arab, Alabama, in 1969, and attended Auburn University from which he graduated in 1973, with a Bachelor of Science Degree in Mathematics and a commission in the United States Air Force. Prior to being assigned to the Air Force Institute of Technology, he was assigned to the Armament Development Test Center as a computer systems design engineer.

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

In 1965, Congress passed Public Law 89-306 establishing a government-wide automatic data processing (ADP) management program. However, in the thirteen years since passage of the law, technological advances have significantly changed the capabilities, costs, and applications of automatic data processing equipment (ADPE). This research effort is a study to determine whether current ADP acquisition and management policies are appropriate for small-scale ADPE. A literature review was used to identify

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the technological changes that have occurred in ADPE since 1965, to determine if the ADP management program was founded on particular technological assumptions, and to identify the present Air Force requirements for the acquisition and management of ADPE. Also, twenty-three interviews were held with ADP managers and ADPE users. These interviews were used to identify and examine current problems in acquiring and managing small-scale ADPE. The writer concluded that while the basic ADP acquisition and management policies remain valid for small-scale ADPE, significant problems exist in the implementation of these policies. It was determined that these problems relate to the increasing number of low cost ADPE acquisitions. It was concluded that ADPE acquisition approval authority needs to be further decentralized and that acquisition procedures need to be simplified.